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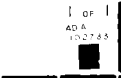

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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the Scientific Literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with, members of the

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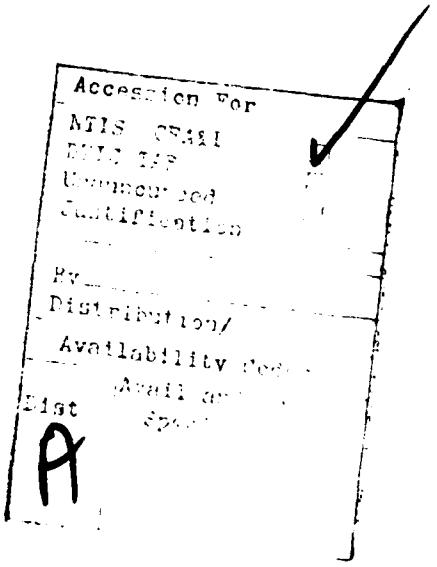


To the readers of *ESN*

Your response to the Readership Survey questionnaire which was within *ESN* 35-2 was much appreciated. The comments and suggestions for improvement are being studied and your suggestions for changes will be implemented if possible. For those of you who have not yet had time to send in the questionnaire, we would still appreciate receiving your completed forms.

AEROSPACE

AERONAUTICAL ENGINEERING AT ISRAEL'S TECHNION

The Israel Institute of Technology, or Technion, is the country's oldest institution of higher learning, having been founded in 1924. It offers degrees in most science and engineering disciplines as well as in architecture, town planning and medicine. Although Hebrew is the official language of instruction, English-language textbooks are used in the graduate courses and all technical publications are in English. Some 1,200 graduates a year leave the Technion which, since 1924, has produced over 20,000 engineers, scientists, architects and physicians. More than 70% of Israel's engineers and scientists are Technion-trained and the 1980-81 enrollment showed 6,000 undergraduate and 3,000 graduate students spread over 20 departments. The faculty numbers about 1,500 at three campuses in the Haifa area. The main campus, Technion City, occupies 300 acres. More than 5,000 applicants per year vie for 1,400 freshman slots. Because all of Israel's young people must complete military service after high school, the average entering age is about 21. Many of the students are married and tuition is paid only by those who can afford to do so.

To encourage research at the Technion, the Technion Research and Development Foundation Ltd. was founded in 1952. It is completely owned by the Technion. The foundation strives to strengthen applied technological research at the Technion by fostering close working relationships between Technion scientists and outside organizations including industry, the defense establishment, and other government agencies. These relationships are promoted in four ways:

(1) The Foundation manages R&D projects, carried out by Technion researchers, under contracts awarded by government and private clients.

(2) The Foundation carries out research at its own laboratories, under contract to government and private clients. There are six such laboratories; one, for example, is the Israel Institute of Metals.

(3) The Foundation is the legal representative of the Technion academic staff in their contacts with industry.

(4) The Foundation acts in a liaison role between Technion researchers and potential clients.

The Department of Aeronautical Engineering, chaired by Dr. Shmuel Merhav, has a staff of 35 professors who instruct about 320 four-year undergraduate students in five fields of study: structures, aerodynamics, propulsion, turbojets and flight controls. In addition the department has five research laboratories under cognizance. These are the Aerodynamic Research Center, Propulsion Laboratory, Combustion Laboratory, Control Laboratory and Structures Laboratory.

The Aerodynamic Research Center has six wind tunnels at its disposal:

(1) A 1 ft. × 1 ft. supersonic blow-down tunnel with fixed nozzle blocks which give test-section Mach numbers of 1.5, 2.25 and 3.0. Test durations are in the 20-second to 1-minute range.

(2) A continuous supersonic blow-down tunnel with a variable throat to give a range of Mach numbers of 1.5 to 4.0.

(3) A 40 cm × 50 cm supersonic blow-down tunnel with variable throat to yield Mach numbers between 1.5 and 4.5, accurate to within ± 0.005 M. Typical test times are about 1 minute.

(4) A hypersonic tunnel, with a preheat section, capable of Mach numbers between 6.0 and 8.0. Its nozzle remains uncompleted because, to date, the Technion has had no reason to conduct tests in that speed regime.

(5) A closed-circuit induction-driven transonic tunnel with a 60 cm × 80 cm ventilated test section. Mach numbers from 0.4 to 1.2 are achievable to within ± 0.006 M for test durations up to 1.5 minutes. A flexible nozzle is planned for this tunnel to extend its Mach-number capability to 1.3.

(6) A low-speed, 1 m × 1 m continuous-flow tunnel which is inexpensive to operate and can generate speeds up to 100 feet per second.

All of the wind tunnels are controlled from a single-room, sophisticated tunnel control center where the operator can regulate the test conditions (air storage

tanks, model attitudes, tunnel sensors, tunnel geometry and Mach number) and the data collection and analysis equipment. Tunnel monitoring and data collection are accomplished via closed-circuit television, schlieren photography, video tape, CRT data plots, a 24-channel Neff analog signal processor and a PDP-11 computer.

The research center makes high-quality wind-tunnel models, for itself and its clients, using computer-controlled milling machines and electrical discharge machinery. Because it could not afford to buy wind-tunnel balances from Europe or the US, the center developed its own balance laboratory. They have a unique capability to produce extremely small, six-component balances which they now market at about half the cost of those produced by US companies. These mini-balances use Constantan (350-ohm) strain gauges and are calibrated for linear and nonlinear errors. Each balance undergoes extensive testing at the balance laboratory which pioneered the technique of testing the balances on a lathe, thus subjecting them to thousands of force/moment cycles before delivery.

Dr. Arnan Seginer, head aerodynamicist, described the department's work in aerodynamics and fluid flow. Many items of data have been collected for slender axisymmetric bodies at high angles of attack. This work began several years ago with Israel's development of the Kfir fighter aircraft, a derivative of the Mirage III. Wind tunnel tests at the Technion revealed the generation of asymmetric body forces from the aircraft's nose at high angles of attack. A "moustache" was added to the Kfir to control vortex generation and thereby those body forces. Other improvements to the Kfir resulting from Technion studies were a fixed canard to generate nonlinear lift and a leading-edge sawtooth to generate vortices over the aircraft's delta wing. Some high-angle-of-attack research continues under USAF sponsorship and ultimately the aerodynamicists hope to use a laser Doppler velocimeter (LDV) to map trajectories and structure of vortices. Seginer also showed me flow-visualization work being pursued in the low-speed tunnel with helium bubbles. The objective is to understand the vortex breakdown phenomenon over lifting wings.

The departments of aeronautical and mechanical engineering have made impressive gains in numerical aerodynamic prediction techniques. The efforts in the former group, headed by Seginer, have resulted in the development of a powerful vortex-lattice-method program which is three-dimensional and can handle most wing planforms with flaps and ailerons, and slender bodies of revolution, with compressibility corrections up to Mach 0.7. It can accurately predict vortex-induced nonlinear lift and is being extended, in conjunction with wind-tunnel experimentation, to include the effects of vortex breakdown. Further refinements of the program to handle "thick" wings, asymmetric aileron deflection and post-stall aerodynamics are in progress. The department is using the program to study several very practical problems which include wrap-around missile fins (e.g., folding-fin missiles), canard and cruciform-fin missile configurations, wing vortex-rudder interference at high angles of attack (e.g., landing approach), stall/spin phenomena, and variable-geometry and "flapping" wings. Dr. Josef Katz of the Mechanical Engineering Department has developed an unsteady discrete vortex method which can deal with separated flow. The program has been used successfully to predict the complex flow field above and behind a stalled wing.

Dr. Merhav, in addition to chairing the Department of Aeronautical Engineering, heads the department's Control Laboratory. Using a Data General *Nova* computer with CRT and locally developed software, the control laboratory has developed an integrated pilot's display for instrument approaches to landing. Three-dimensional CRT graphics provide the pilot with a tunnel-like display. He flies the aircraft to stay centered in the tunnel. Attitude, altitude, heading and airspeed information also are displayed. The integrated tunnel display makes even the most complicated approach course easy to fly. Merhav himself has just completed the analysis of a low-cost inertial measurement concept which would provide highly accurate rate and acceleration information without the use of expensive gyros. The idea involves rotating a triad of accelerometers so that they sense not only linear accelerations, but also Coriolis forces resulting from angular accelerations of the vehicle. Merhav concludes that the concept is feasible because very-low-drift amplifiers are now commercially available. Other investigations underway in the Technion's Control Laboratory include precise weapon pointing and vehicle steering during severe aircraft buffeting (e.g., during helicopter landings aboard ship), and development of a remotely-piloted vehicle (RPV) simulator for training RPV operators.

The Technion's Propulsion Laboratory has four hot test cells which are individually controlled from a safe control room. Dr. J. Timnat, who heads the lab, explained that the aim is mainly basic research rather than hardware development. Experiments in progress include the evaluation of a T-shaped combuster built to measure instabilities in solid propellant combustion, and a nozzle lined with a synthetic insulation material being tested for its durability under high exhaust temperatures. In the laboratory's safe working spaces, several new research tools are being developed. A one-dimensional LDV with its associated PDP-11 computer, is being used to measure axial flow velocities in reacting and non-reacting flows. In addition, high-speed photography is employed to study the burning surfaces of solid propellants. The latter study has application to solid-fuel ramjets which the Technion is studying.

The Combustion Laboratory, headed by Dr. J. Goldman, is in its eighth year of investigating turbulent flame. In a country faced with high energy costs, combustion efficiency is extremely important. Pulverized coal, atomized oil, and mixtures of both are under study to increase their efficiencies in energy production. The Combustion Laboratory has also built a valveless pulse jet that currently is kerosene fueled and ultimately will operate on natural gas. Its rectangular cross-section is designed for easy measurement of two-dimensional unsteady flow parameters, and the entire tube can be photographed via a high-speed camera which is part of the test apparatus.

About five years ago under sponsorship by the Israeli Air Force, Prof. Josef Shinar, an aerodynamicist, began studying the problem of missile avoidance systems and techniques to be used by maneuvering aircraft. He received partial sponsorship to expand his work, and he is currently engaged in all aspects of the problem: missile trajectories and dynamics, aircraft evasion maneuvers, missile processing capabilities, aircraft signatures, missile seekers and electronic warfare. He is trying to answer the difficult question: what is the minimum information required by a missile to develop an effective guidance law, and what are the sensitivies of the guidance parameters?

Working closely with the Israeli Air Force and Israel Aircraft Industries, the state-owned aircraft company, the Technion Department of Aeronautics has attained impressive expertise in a variety of aeronautical disciplines. The department's research is careful and thorough, taking full advantage of the latest research equipment and techniques. They are conscious of the operational needs of their military pilots, and are most adept at finding quick and clever solutions to real-world aeronautical problems. (J.A. Strada)

CHEMISTRY

THE FARADAY DISCUSSION NO. 70: PHOTOELECTROCHEMISTRY

Faraday Discussions differ in format from other types of professional meetings. The papers for discussion are distributed to the participants for review in advance of the meeting. Presentation by the author(s) at the actual discussion consists of highlights and key points. The bulk of the time allotted to each paper is devoted to discussion from the floor.

The Faraday Discussion No. 70 was held at Oxford University on 8-10 September, 1980. The Discussion involved 180 scientists, of whom 100 were from outside Great Britain. The large number of participants attests to the international interest in the topic. The proceedings,, which include much of the discussions, will be published in July 1981 (available at a cost of $42.30 from the Royal Society of Chemistry Distribution Centre, Blackhorse Road, Letchworth, Herts., SG6 1HN). Consequently I highlight only certain aspects of the Discussion in this report.

Dr. A.J. Nozik (Solar Energy Research Inst., Golden, CO) provided the opening comments. To some extent, his presentation set the tone for the meeting, which was definitely slanted toward those aspects of the subject which bear on solar energy devices. Other applications such as photoelectrosynthesis, microheterogeneous redox chemistry, photoetching, and photodeposition were mentioned briefly but not discussed. Regarding photogalvanic and electrochemical photovoltaic devices, conversion efficiency is the property which dictates the present research orientation. The goal appears to be an efficiency greater than 25% when concentrators are used and 20 to 25% efficiency in the absence of concentration. Single photoelectrode systems are presently much less efficient. The photoelectrolysis of water has been accomplished with about 4 to 6% efficiency and photovoltaic applications of photoelectrochemical cells are now nominally at the 6 to 7% level. Research emphasis is now being placed on the energetics of the systems, surface modification, catalysis, new materials, novel chemistry, cascaded cell systems, and multiple absorber arrangements.

Dr. John O'M. Bockris (Texas A and M Univ.) provided the wrap-up for the meeting. He elected to cite five of the presented papers for discussion as highlights of the meeting.

While other papers probably were equally significant, the five identified by Bockris did provide information important to the understanding of the topic and also provided bases for future work and development in the field. Accordingly, before discussing some of the other papers, I include here a brief comment on the papers recognized by Bockris and the rationale for his selection of them for comment.

The first cited paper, presented by Dr. H. Tributsch (CNRS, Mendon, France), discussed the photoelectrochemical behavior of layer-type transition-metal dichalcogenides. Tributsch observed that there is enhanced photoelectrochemical reaction with water when the holes (h+) produced by irradiation are in the d-bands of semiconductors such as MoS_2, WS_2, and WSe_2. Holes produced in d-states appear to be less efficient at causing photocorrosion. This work demonstrates the importance of d-d transitions in the operation of such systems and provides additional information necessary to design new semiconductor materials with improved characteristics. It should be noted that other researchers such as Dr. J.B. Goodenough (Oxford Univ.) and Dr. A. Wold (Brown Univ.) have also been examining semiconductor properties relative to their electronic structures and using chemical methods for tailoring their properties.

The second paper cited was presented by Dr. B.A. Parkinson and coauthored by T.E. Furtak, D. Canfield, K. Kann, and G. Kline (Department of Energy Ames Laboratory, Iowa State University). The paper, entitled "Evaluation and Reduction of Efficiency Losses at Tungsten Diselenide Photoanodes," reported the use of a new probe technique, a scanning laser spot, to measure the sites where losses in efficiency occur in photoelectrochemical cells. The method employs photocurrent spectroscopy and has been used to demonstrate the existence of surface states in tungsten diselenide electrodes. These surface states are associated with edge sites. Energetically, they are located near the conduction band and are apparently in rapid communication with it. These states are responsible for the reduction in conversion efficiency in these layered semiconductors. Chemical methods for modification of the surface states were employed and gave at least temporary improvements in efficiency.

The most definitive work on semiconductor surface state/recombination site neutralization via chemical treatment or modification has been carried out by a group at the Bell Laboratories. That work was the subject of the third paper cited by Bockris. Dr. B. Miller reported the results of the research done in cooperation with A. Heller, S. Menezes, and H.J. Lewerenz in a paper entitled "Surface Modification in Semiconductor-Liquid Junction Cells." This group has dramatically demonstrated major improvements in the efficiency of gallium arsenide photoelectrochemical cells via surface modification techniques. It has been shown that treatment of the GaAs with ruthenium, or with ruthenium followed by lead (from solutions), enhances the operation of the semiconductor through the reduction of electron-hole pair recombination at grain boundaries by alteration of the surface state distribution.

The fourth paper cited, by Dr. M. Grätzel (Inst. of Physical Chemistry at the Ecole Polytechnique Fédérale de Lausanne, Switzerland), was entitled "Light Induced Charge Separation and Water Cleavage in Microheterogeneous Aqueous Systems." Grätzel is one of the pioneers in the use of micellular assemblies or sols in photoelectrochemical systems. He has addressed the use of these systems for the photoelectrolysis of water to hydrogen and oxygen. In this, his latest paper on the subject, he stated that he had recently employed sols consisting of titanium dioxide (TiO_2) particles with platinum and ruthenium dioxide (RuO_2) regions on the surface. In one such system, the RuO_2-doped TiO_2 portion serves as the oxygen catalyst, whereas hydrogen is produced at the platinum-coated region of the electrode. In this system, methylviologen is used as an "electron relay" between the TiO_2 and Pt. A portion of his paper, which summarizes much of his earlier work, involved the elucidation of the mechanism and the exploitation of micellular systems for carrying out photoinduced electron transfer for hydrogen production.

The last paper cited by Bockris was one by Prof. Melvin Calvin (Univ. of California, Berkeley) entitled "Synthetic Chloroplasts." Calvin is a Nobel laureate and has devoted much of his active research career to the study of photoinduced processes, most recently in the synthetic chloroplasts area. This is an outgrowth of his research on photosynthesis. Calvin highlighted the development of a manganese-containing catalyst for oxygen production. The catalyst is a tetrapyridylporphyrin manganese (III)

complex. When used in conjunction with methylviologen, the system was observed to undergo photoinduced electron transfer from the porphyrin to the methylviologen with subsequent oxidation by the resultant manganese species of water (or whatever the oxidizable substrate happened to be) to oxygen. Calvin has proposed the use of the catalyst for the commercial production of propylene oxide through the use of propylene as the substrate. Such a use would have a significant impact on the economics of poly(propylene oxide) production.

Some other material presented at the Discussion deserves comment and could, in my opinion, have been cited as highlights of the meeting. Dr. A.J. Bard and his co-workers (Univ. of Texas) presented additional evidence in support of Fermi-level pinning in selected semiconductors. The impact of this presentation on those attending the Discussion was somewhat reduced by the fact that the concept had been published earlier by Bard and by Dr. M. Wrighton (MIT). This work was a major contribution to the field in that it characterized one of the more significant effects of surface states on the behavior of semiconductors in photoelectrochemical cells. The Fermi level, and hence the available photovoltage in cells where the level pinning occurs, is determined by surface states rather than the solution redox couple.

Dr. S.P. Perone and co-workers (Purdue Univ.) with S.B. Deutscher and J.H. Richardson (Lawrence Livermore Laboratories) have been trying to establish the kinetics of the various processes responsible for the operation of photoelectrochemical cells. They have been using pulsed laser-induced photoelectrochemistry and concentrating on the production and detection of the transient phenomena in the nanosecond-to-microsecond time regime. The results presently suggest that the photoinduced charge transfer is essentially coincident with the laser pulse (10 nsec).

The final paper noted here is that of Prof. H. Gerischer (Fritz-Haber Inst., Berlin, FRG). He addressed the topic "Photodecomposition of Semiconductors: Thermodynamics, Kinetics, and Application to Solar Cells." Gerischer has been one of the leaders in this aspect of the topic. In his paper he addressed specifically the photodecomposition process. He pointed out that in order to analyze the photodecomposition tendency, it is necessary to consider variations in the voltage drop in the Helmholtz double layer caused by the redox electrolytes or by illumination. According to Gerischer, it is most likely that any influence will be unfavorable in that the shift will make the minority carriers at the surface more reactive. Addition of a surface charge of opposite sign to the minority carriers could, however, lead to an increase in stabilization. Such modifications need to be identified.

As a part of his wrap-up, Bockris offered his opinion regarding possible areas for future research in the field. It probably can be said that these areas would be the same ones identified by most scientists familiar with the field. They are: (1) exploration of the solution side of the double-layer and its influence on the photoelectrochemical process, (2) quantitative characterization of surface states, (3) methods other than Mott-Schottky plots for determining flat band potentials, (4) transient measurements, (5) electronic state energy tuning using nonaqueous solutions, (6) new theoretical models, (7) Fermi-level concepts in solution, and (8) kinetics aspects of photoelectrochemical devices. (Jerry J. Smith, ONR Code 472)

PHOTOCATALYZED WATER-SPLITTING AT THE INSTITUTE FOR ORGANIC CHEMISTRY TNO, UTRECHT

The development of a practical and efficient photochemical process using solar energy for splitting water into hydrogen and oxygen would provide a virtually inexhaustible source of a clean fuel. Recognition of this fact has prompted intensive research efforts in many countries. One of the research programs in Europe on photoelectrolysis is at the Institute for Organic Chemistry TNO in Utrecht, The Netherlands. This institute was founded in 1946 as a part of the Central Organization for Applied Scientific Research TNO in the Netherlands or, as the Dutch refer to this organization, simply the TNO. (The acronym TNO is derived from "Taegepast Natuurwetenshcappelijk Onderzaek," the English equivalent of which would be "applied scientific research.") TNO was established in 1931 with the goal of encouraging and supporting scientific research as applied to national needs because the Netherlands at that time was highly dependent on foreign countries for industrial products and technology.

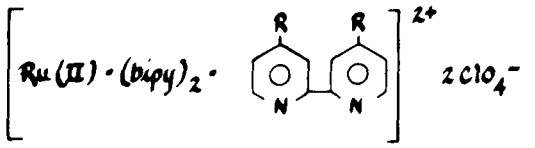
Early growth was slow with only 313 people employed by TNO institutes in 1945, but by 1976 total employment had risen to 4,850 with approximately 1,000 academic degree-holders. There are now 35 TNO institutes in the fields of mathematics, physics, chemistry, industrial

research, nutrition and food, health research, and national defense. Support for TNO institutes comes not only from government grants, but also from contract research for industry. In 1977 the total budget of TNO was 400 million guilders ($160 M).

Many of the institutes are quartered in or near one of the Dutch universities, as is the case with the Institute for Organic Chemistry which is located adjacent to the Department of Organic Chemistry at the State University of Utrecht. The institute has research programs in: (1) organic synthesis, (2) polymer chemistry, (3) organometallic chemistry, (4) biochemistry and microbiology, and (5) photochemistry. The institute not only is involved in research on new methods of preparation but also carries out custom syntheses of starting materials, intermediates, and development chemicals on both laboratory and semitechnical (up to 25 kg) scales. The photochemical research is focused in two general directions: (1) synthesis of fine chemicals by photocatalytic methods using transition-metal complexes and (2) the photochemical production of hydrogen and oxygen from sunlight (water-splitting) with transition-metal complexes and semiconductors. The program on solar energy conversion was initiated at the institute in 1976 with financial support from the VEG-Gasinstituut, a Dutch foundation, and from the solar energy program of the Commission of the European Communities (CEC). (Information about the solar energy program of the CEC can be obtained through its newsletter, *Solar Europe*, which is available to interested parties from the Commission of the European Communities, Directorate-General XII for Research, Science and Education, Rue de la Loi 200, B-1040 Brussels, Belgium.)

The staff for this project at the institute includes Dr. A. Mackor (leader), Dr. Thewissen, and Dr. A.H.A. Tinnemans with 4 technical assistants. This group has taken three approaches to their research on photochemical splitting of H_2O: (1) tests of monolayer devices formed from ruthenium(II) tris(bipyridine) surfactants; (2) studies of the generation of hydrogen or oxygen in sacrificial systems with particular emphasis on the possible utility of binuclear Ru-Ru complexes in the oxygen-forming part of a water-splitting system; and (3) investigations of single-crystal and powdered semiconductors such as TiO_2 and $SrTiO_3$, the spectral response of which has been shifted to the visible either by doping with transition metals or by applying a water-insoluble ruthenium(II) tris(bipyridine) dye to the surface of the electrode.

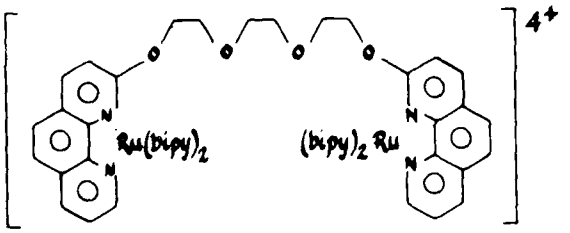
The research on the possible use of monomolecular layers of transition metal complexes as catalysts for splitting water with sunlight has employed derivatives of ruthenium(II) tris(2,2'-bipyridine) dyes, $Ru(bipy)_3^{2+}$. These sensitizers have attracted worldwide attention in the last few years because they not only exhibit a strong absorption in the visible region ($\lambda_{max} \sim 450$ nm), but also are thermodynamically capable of producing both hydrogen and oxygen from water. For the monolayer studies, the 4,4'-dialkyl-substituted bipyridine ruthenium complex *1a* was synthesized. This sensitizer, shown below, exhibits photolytic stability over ester complexes such as *1b* that have been used by other investigators. However, in line with recent results from other laboratories, Mackor and his collaborators have not found the ruthenium surfactants in monolayer assemblies to be active photocatalysts for water-cleavage.



1a, R = $-C_{19}H_{39}$

1b, R = $-CO_2C_{18}H_{37}$

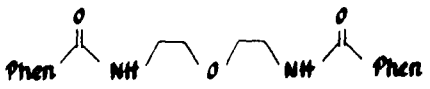
Because it is felt that the problematic step in the photochemical splitting of water is the formation of oxygen and not hydrogen production, this group has initiated a study of Ru-Ru binuclear complexes. These sensitizers may be particularly useful in two-photon and/or two-electron processes in the photocatalytic generation of oxygen from water. Syntheses of 10 phenanthroline derivatives which form stable multinuclear ruthenium complexes such as 2 have been achieved. Several of the ligands L that have been prepared and used for these complexes are shown in the following figure. It is thought that ligands containing ethylene glycol units may form semicyclic structures due to gauche-gauche interactions in the chain. The corresponding dinuclear complexes ($[bipy]_2RuLRu[bipy]_2$) have been prepared by reaction of the free ligand with *cis*-$(bipy)_2RuCl_2$.



2

ligands L

$(Phen-OCH_2CH_2)_3N$



These workers believe that one advantage of these simple open-chain ligands is that the Ru-Ru distance in the complexes can be systematically varied. The efficiency of the production of oxygen in photochemical water-splitting may be a function of this distance.

A very promising result has come from a collaborative study of the binuclear complex 2 by the Utrecht group and Prof. M. Grätzel's laboratory (Institute of Physical Chemistry, Lausanne) using flash photolytic techniques in conjunction with a sensitive oxygen detector. Complex 2 was irradiated in the presence of $Co(NH_3)_6^{3+}$ in order to prepare *in situ* the binuclear Ru^{3+} complex according to the reaction:

$$(bipy)_2RuLRu(bipy)_2^{4+} + 2Co^{3+} \xrightarrow[450nm]{h\nu} \underset{2}{} (bipy)_2RuLRu(bipy)_2^{6+} + 2Co^{2+}$$

A preliminary photochemical experiment has provided evidence for the evolution of oxygen in homogeneous aqueous solution *at pH 7* without the requirement of any additional catalyst. It was found, in contrast, that mononuclear Ru(II) tris(bipyridine) does not exhibit this reaction. The two adjacent catalytic ruthenium centers are therefore apparently able to act cooperatively to effect the oxidation of water. A thorough study of the electrochemical properties of these multinuclear complexes using pulse polarography and cyclic voltammetry has been carried out by Tinnemans in cooperation with J.G.M. van der Linden, J.E.J. Schmitz, and A.A. Saaman (Univ. of Nijmegen, The Netherlands).

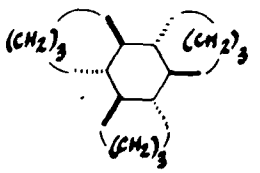
Many investigators in this field believe that a key to the practical realization of water-splitting with solar energy lies in the development of stable and efficient semiconductor electrodes. Several groups including the one at Utrecht have therefore focused attention on TiO_2(rutile) and $SrTiO_3$ electrodes. These materials exhibit high photostability. Further, the conduction bands are at energy levels which are sufficient to produce photoelectrolysis of water. Unfortunately, these semiconductors do not absorb significantly in the visible region due to their large band gaps (3.0 and 3.2 eV, respectively), corresponding to absorption edges of 400 and 380 nm, respectively. These materials therefore cannot be used effectively for water-splitting with solar radiation. The group at the institute, as have other groups, has directed its efforts at solving this problem by extending the spectral response of the photoanode into the visible through sensitization by (1) applications of layers of transition-metal dyes on the surface of the electrode or (2) by impurity doping on the surface or through bulk doping. Using this latter approach, Mackor and Prof. G. Blasse (Dept. of Solid State Chemistry, State Univ. of Utrecht) have collaborated on a study of the visible light-induced photocurrents, a measure of the photoelectrolysis of water, obtained with a bulk-doped single crystal of $SrTiO_3$: $LaCrO_3$ (500 ppm). This crystal functions as the photoanode. In this doped crystal, Cr^{3+} ions substitute for Ti^{4+} ions in the crystal lattice with simultaneous charge compensation achieved by substitution of La^{3+} for Sr^{2+}. After oxidative heat treatment of the commercially available crystal, the original blue-black crystal becomes transparent and changes to a brown color. The optical absorption spectra of the oxidized crystal exhibits a weak broad band with a maximum at approximately 650 nm and an intense absorption in the region of 400 to 500 nm. The 650-nm band is believed to result from the $^4A_2 \rightarrow {}^4T_2$ transition of the

$Cr^{3+}(d^3)$ ion, while the higher energy band is ascribed to a $Cr^{3+} \rightarrow Ti^{4+}$ charge-transfer transition in which an electron from Cr^{3+} is excited into the conduction band of $SrTiO_3$. It is thought that the latter transition is responsible for the observed photocurrents. Measurements have been made of the photocurrent spectrum and photocurrent-voltage curves of the doped electrode in 0.5 M H_2SO_4. It was observed that the appearance of the photocurrent requires a higher bias voltage than was previously found for undoped or Nb-doped $SrTiO_3$. Also, the photocurrents are considerably lower in magnitude for both band-gap (325 nm) and visible light (460 nm) excitation compared to undoped or Nb-doped $SrTiO_3$. These results do, however, indicate that doping of $SrTiO_3$ by $LaCrO_3$ can extend the photoresponse of the semiconductor into the visible region.

Blasse and Mackor have investigated extensively the coloration that results upon the surface of doping titanates and zirconates with transition-metal ions by means of diffuse reflectance and electron spin resonance spectroscopy. Powders of several titanates ($SrTiO_3$, $CaTiO_3$, $MgTiO_3$) and zirconates ($CaZrO_3$, $SrZrO_3$) were doped with Cr^{3+}, Ni^{3+}, and Mn in the divalent, trivalent, and tetravalent states. The preparation of the surface-doped materials involved a firing at 1200°C of intimate mixtures of the titanate or zirconate with the dopant. A solid solution is thereby produced on the surface with the introduction of the dopant into the crystal lattice of the host. It has been found that only the Cr^{3+} ion leads to an intense coloration of the titanates as a result of the $Cr^{3+} \rightarrow Ti^{4+}$ charge-transfer transition.

A series of experiments have been carried out to test the feasibility of sensitizing $SrTiO_3$ single crystal electrodes by a thin film of the water insoluble Ru(II) $(bipy)_3$ derivative 2 described above. Several hundred dye layers were applied to the electrode by evaporation of a solution of 2 in 2-propanol. Sustained photocurrents were measured upon irradiation of the coated electrode in 0.5 M H_2SO_4 at 460 nm, the absorption maximum of the dye. These results with the coated sensitizer are encouraging because other investigators have obtained negative results with solutions of water-soluble Ru(II) $(bipy)_3$ and $SrTiO_3$ electrodes. Measurements of the photocurrent as a function of pH, potential of the photoanode, and irradiation wavelengths have been made. The magnitude of the sensitized photocurrent at 460 nm has been found to be approximately 100 times smaller than the band-gap current measured at 325 nm. For comparison, an $SrTiO_3$ electrode was coated with a thin film of Ru(II) tris(4,4'-dinonadecyl-2,2'-bipyridine) hexafluorophosphate. No sensitization was observed with this more heavily substituted dye, an observation attributed to an action of the alkyl chains as insulation between the dye and the semiconductor, thereby inhibiting electron injection into the semiconductor.

Other types of photocatalytic reactions are also under study at the institute. Mackor, T. Spee, and J.Th.M. Evers have recently investigated the mechanism of the copper(I) trifluoromethanesulfonate-catalyzed photochemical formation of a cycloheptene trimer. These workers have shown that the reaction is a two-step process involving a photochemical *cis-trans* isomerization of cycloheptene coordinated to copper. Subsequently, under the conditions of the photoreaction or in the dark at 40-60°C, a cyclotrimerization occurs to form the all-*trans* trimer 3 in 80% yield. A novel concerted mechanism for the trimerization is proposed by Mackor involving a complex of a central copper ion with three *trans*-cycloheptene ligands and formation of the trimer in a "template" reaction.



3

Mackor and Tinnemans are beginning an investigation of the sensitized photoreduction of carbon dioxide and other compounds to methanol. A powder of $SrTiO_3 \cdot RhO_2$ has provided some very encouraging results with photochemical conversions of formaldehyde to methanol in water of 10%.

In summary, although the solar energy conversion project at the Institute for Organic Chemistry TNO was initiated only relatively recently, it is apparent that this group will be able to make significant contributions to the development of a practical and efficient method for water-splitting with solar energy. The initial results with the multinuclear complexes are particularly intriguing. (A. Paul Schaap)

COMPUTER SCIENCE

DISTRIBUTED MULTI-MICROPROCESSOR PROTOTYPE IN PISA

Introduction

The physical sciences and engineering part of the Italian Consiglio Nazionale della Richerche (CNR) consists of six major institutes and 45 affiliated laboratories and research centers, some situated apart from the major universities, others collocated with those universities. Recently, the CNR R&D budget increased fourfold; the current average support per researcher is approximately $100K per annum.

There is a CNR-sponsored national computer science program coordinated by the Istituto di Elaborazione della Informazione (IEI) in Pisa. The program is divided into three parts with designated lead organizations shown below:

(1) Distributed Multiprocessor Development - IEI

(2) Computer Standardization - Istituto CNUCE (a CNR-supported center in Pisa)

(3) Mail & Telecommunication - Ministry of Post and Telecommunications.

For the first part, three parallel development teams are involved in a 5-year "fly-off": (1) the Pisa team: IEI, University of Pisa, University of Rome, and Selenia (an Italian firm); (2) the Turin team: headed by a CNR center within the Istituto Elettrotecnico at the Polytechnic of Turin (3) the Milan team: Polytechnic of Milan, University of Milan, and Honeywell S.p.A. The 1980 budget for the project was $2 million. The effort of the Pisa team is described below.

The Pisa team consists of the following organizations pursuing research and development in interrelated areas:

Istituto di Elettronica, University of Pisa - Architecture

Istituto di Automatica, University of Rome - Virtual Addressing

IEI - Fault Tolerant Design

Istituto di Scienze dell'Informazione, University of Pisa - Operating System

Selenia (Pisa office) - System Prototype (using Zilog Z80 microprocessors).

System Architecture

The Pisa effort known as MuTEAM (μ for multi-micro) is to develop a prototype system scheduled to be tested in 1981. The prototype is intended to be used to study the integrated design methodologies for distributed multi-microprocessor systems including fault tolerance and operating system (OS) kernel requirements.

The system assumes a hierarchical structure of several "virtual" levels from user interface to hardware printed circuit boards. The highest virtual level is the user process level. At this level, let $\{P_i\}$ be a set of processes which are executed by a set of lower-level functional computation modules (hardware or software), $\{C_i\}$. In order to eliminate mutual interference among the P_i, protective "rings" are inserted in $\{C_i\}$ for each higher-level user.

Separation between processes and a set of methods by which subsystems operations can be monitored are necessary requirements for an operational system diagnostics capability. System diagnosis is assigned to the next abstract level in the hierarchy. The system diagnostic technique used in the MuTEAM design avoids the conventional need of a central "hard-core" (hardware or software) to assure the correctness of diagnostic decisions. The following elements are the significant characteristics of this technique:

(1) Each unit having a logical identity in the system is locally responsible for its decision relative to the system diagnosis, and the diagnosis is globally validated by the cooperation among the units.

(2) The behavior of units is "nonaggressive," that is, no unit in the system is given the means, for example, to disconnect some other unit from the power bus. Malfunctioning units are simply ignored by closing the communication channel connected to them by each of the connected units, independently.

The next virtual level is the operating system (OS) kernel level. It is responsible for managing the logical communication channels. The interprocess communication is based on message passing because, too frequently, the shared variable approach leads to unplanned accidents.

A message-passing-based OS kernel allows process interactions only through explicitly referenced channels. A channel can be opened for a specific type of information exchange; this enables the kernel to control dynamically the correctness of channels during operations.

The hardware level comes next. Among the initial specifications developed by the MuTEAM project was the requirement for wideband communications through a parallel bus. It was recognized later that such information exchange is required only within groups of a limited number of processors while

intergroup communications are at much lower rates. Consequently, a clustered architecture was chosen: some of the elements of $\{P_i\}$ are executed by a computing element C_i through its associated OS kernel which is implemented in the same C_i. Interprocessor communications among a "cluster" of C_is are effected via the parallel bus and shared memory. Protective rings again must be inserted in the computing elements via the OS kernel. Therefore, two-state (user and executive) processors become a requirement for the $\{C_i\}$.

System Prototype

The system is configured in clusters, interconnected by serial channels. Each cluster consists of up to 16 computing elements (or nodes) communicating through a parallel (cluster) bus. The clusters are transparent at the OS-kernel level. Therefore, the system can be considered as a set of identical virtual nodes. In addition to the parallel data bus, there is a "signalling bus" for interprocessor interrupts. Conventional off-the-shelf components are used. The main components of a node are: the CPU - (Zilog Z8001), address translator (AT), shared memory, private memory, I/O, communication controller (CC), and cluster bus arbitor.

Only the virtual addressing and memory protection subsystems warrant further discussion. The virtual space contains 32K shared segments partitioned into 32 blocks, 16 blocks of shared segments and 16 blocks of private segments, where each block contains up to 1K segments. Each node has a shared block and a private block. The segment's virtual name, generated in a node, can access any shared block, but only its own private block. There are 1K 15-bit registers in AT to specify block and segment addresses. The complete virtual address is a 10-bit virtual name and a 16-bit offset. A relocation unit translates the complete virtual address into a 20-bit physical address in the shared memory. The relocation unit consists of 1K 32-bit registers, each organized in two 16-bit fields to specify the limit and base of the segment. A similar relocation unit is included in the private memory and I/O subsystem.

A protection unit controls the access for protecting shared segments. The protection unit consists of 1K 32-bit registers. Each register specifies the access list for a segment belonging to the shared block. An access-violation checker compares the access with the rights of the accessing processor on the specific segment.

Summary Comments

The MuTEAM prototype development appears to be progressing on schedule. The cluster architecture approach has been demonstrated successfully elsewhere in Italy in a special-purpose postal application (for automatic address recognition: see *ESN* 35-3:107 [1981]). The same low-risk approach for the MuTEAM prototype construction is noted.

The prototype, however, represents only a test vehicle for fault-tolerant concepts and OS-kernel designs. The hard part of the project is just beginning. This author intends to investigate the activities of the Milan and Turin teams on this project, to monitor the progess of all 3 teams, and to report on those activities in later *ESN* articles.

One cannot help but marvel at the management approach of the entire multiprocessor development project. US Government agencies are accustomed to competitive procurement procedures; the competitive efforts of government-university-industry consortiums involved in a 5-year, 3-way fly-off in Italy are quite novel. Design by committee appears to be a standard procedure. The coordination effort must be horrendous. When one of the Pisa team participants was asked to comment on this particular point, he allowed that, inasmuch as almost all organizations on their team are situated around the Piazza di Miracole (Square of Miracles, where the famous leaning tower is located), a miracle may occur for the project. (Y.S. Wu)

KARL—A HARDWARE DESIGN LANGUAGE FROM THE UNIVERSITY OF KAISERSLAUTERN

KARL is the acronym of a particular high-level hardware description language. Its statements are interpreted to describe building blocks and their interconnections in a block-diagram language (ABL) for graphic representation of digital circuits. A KARL description of a device is used as input to a simulator, and the simulator checks the validity with respect to an ABL diagram. The latter is then used as input to a graphic mask-generation system for computer-aided design (CAD).

KARL was originally described by Prof. Reiner W. Hartenstein as Karlsruhe Automatic Register Language (KARL-1) in *Fundamentals of Structured Hardware Design* (North Holland/American Elsevier, Amsterdam/New York, 1977). Hartenstein is presently associated with the University

of Kaiserslautern in West Germany, where he has re-written KARL-1 into KARL-2, a PASCAL version, with a new parser and also with improvements, for use in the design of large-scale integrated circuit (LSI) devices, suggested by the semiconductor components industry. At this time, Hartenstein is a visiting professor at the University of California, Berkeley (UCB), and while there, he is integrating KARL-2 with the LSI-cell library of Xerox's Palo Alto Research Center. Just recently, he succeeded in operating KARL-2 on UCB's PDP-11/VAX780 through the UNIX operating system.

KARL has been widely accepted by the European community. A KARL-1 compiler using SIMULA 67 has been implemented on the Univac 1108 system at the Istituto di Elettrotecnica ed Elettronica, Polytecnico di Milano. A comparative study of KARL-1's utility in student hardware design productivity was completed at the University of Trondheim (Norway). In Sweden, the Royal Institute of Technology has produced FORTRAN versions of KARL-2 on both the PRIME 750 and VAX-11/780 systems. These have been tested in conjunction with ASEA HAFO, a Swedish manufacturer of CMOS semiconductor designs.

The KARL language design philosophy as described in "KARL, A Hardware Description Language As Part of a CAD Tool For LSI", R. Hartenstein, et al., *4th International Symposium on Computer Hardware Description Languages*, Palo Alto, Ca., October 1979, is excerpted below:

A basic principle for the design of such a descriptive language is that the description of the hardware system should be on a level high enough to prevent the designer from being overburdened by details. In most cases, a description of the system up to the register-transfer (RT) level is sufficient. A symbolic, parsable hardware-description language like KARL provides such a description for use in designing LSI devices by CAD (computer-aided design) systems. However, believing that "a picture is worth a thousand words", one is drawn to the conclusion that it is also desirable to have an implemented block-diagram description language such as ABL. This means that two forms of description are needed:

(1) a diagram showing the topological layout of the RT elements and their interconnections.

(2) a symbolic description, showing the relations between the various subsystem elements and RT-level components of the system.

In the US, description languages, e.g., the Instruction Set Processor (ISP) developed by the Carnegie-Mellon University, address only (2) above. ISP is an input language for a simulator which operates either at the gate level or at the RT level. KARL has a broader goal: Not only is it to be used for simulation at the RT level, but there is also a set of graphic symbols forming a block-diagram language which relates each ABL symbol to statements in KARL. Apart from the freedom of topological layout, an ABL diagram can be tested for consistency by checking the corresponding KARL description.

KARL is a university-developed LSI-device design language. It is very well instrumented and works. However, its real success depends upon acceptance by the LSI industry. Traditionally, the industry has considered computer-aided design systems as being proprietary to the company that developed them. Therefore, resistance to KARL is to be expected in industry. However, its use in education may thrive. (Y.S. Wu)

ENGINEERING

ANTENNAS FROM TURIN

Turin's Istituto di Elettronica e Telecommunicazioni (IE&T) was described by Philip Fire recently in these *Notes* (*ESN* 34-9:424 [1980]) as was the Centro Studi e Laboratori Telecommunicazioni S.p.A. (CSELT, *ESN* 34-7:360 [1980]) which he called "Bell Labs Italian Style." In this article I describe a visit to the same two establishments to learn about their work in microwave antennas and associated devices.

IE&T is part of Turin's technical university (Politecnico di Torino) and is the equivalent of an electronics-oriented EE department. The politecnico has about 5,000 students of whom about 1,500 are in IE&T, which has 28 full and assistant professors. Interwoven with the research activities at the university in the field of antennas and propagation are the research activities of CESPA (Centro Studi Propagazione e Antenne—Center for Propagation and Antenna Studies) which is a research center of the National Research Council of Italy. There are about 10 people on the research staff of CESPA, most of whom are also on the staff of the university. Both organizations freely use each other's facilities. It is a way of tapping the expertise found at the university to tackle problems of national rather than of purely scientific interest and of providing a channel for funding. Ample funds seem to be available. A rather similar system, though more complex,

was found at the Technical University of Trondheim (*ESN* 34-12:558 [1980]).

My host for the visit was Prof. Ing. Rodolfo Zich, who is professor of electromagnetic fields, chairman of the honors course, and director of CESPA. He is also a consultant to CSELT, which is discussed later in this article. Zich spends about 40% of his time on administration, and the rest he divides evenly between teaching and research. He discussed some of his research work on corrugated horns, which was funded by CSELT. Corrugated electromagnetic horns can give radiation patterns that are the same in both the E- and the H-planes and therefore are specially suited for circular polarization applications where a high level of polarization purity must be maintained. Zich's work is of particular interest for satellite communication systems where polarization diversity is used to provide separate channels, thus doubling the overall capacity. He found the most important part of the design to be the transition from the waveguide to the corrugated horn, particularly for broadband applications. The work, which was theoretical, used Wiener-Hopf techniques to calculate the scattering matrix of the discontinuity and employed numerical methods, all at first limited to circular, corrugated horns. Zich and his co-workers found they could obtain a bandwidth of 1.5:1. The work has now been extended to horns of arbitrary cross-section. The theory has been checked experimentally through the efforts of CSELT for circular horns and excellent agreement was claimed. Elliptical horns, which radiate elliptical beams, are very difficult to construct (some were built at the University of Eindhoven, *ESN* 34-5:226 [1980]) but it is intended to investigate them at CESPA in a study for a thesis.

Aircraft radar cross-sections are being studied theoretically with funding from Aeritalia S.p.A. The approach primarily uses GTD (geometric theory of diffraction) which Zich believes to be adequate, but they also use physical optics. The aircraft is assumed to be made up from a number of elementary bodies which are superimposed. The same firm also funds some research on radomes, and there the aim is to find a design giving minimal losses.

I was introduced to Dr. Mario Orefice, who is an assistant professor at the university, specializing in antennas, and who also works on the CESPA team. He has been involved in the design of large reflector antennas and in particular has studied scattering by the rim of the reflector which affects the off-boresight radiation characteristics. Using GTD, he has developed a program that can be used on a minicomputer and with it has shown that shaping of the rim can lead to side-lobe and back-lobe reductions. Other attempts to improve the performance of the reflector by modifying the rim, this time with dielectric, were reported by workers from the University of Naples at the 10th European Microwave Conference.

The use of a minicomputer in the reflector calculation was not accidental. The university computer, which is administered by a consortium, has been continuously increasing its charges. Orefice said that they have found it to their advantage to turn to minicomputers that are dedicated to a particular group. Most of their budget went to purchase a $40,000 PDP 11/34 computer with 128 K memory, with the next budget planned to supply 4 to 6 video display terminals and printers. It will be used by the research staff and also by students working on their theses.

Orefice has been working on two-dimensional waveguide arrays with inclined series slots in the center of the broad wall. He has developed a computer model to design such arrays using rapidly converging iterative techniques and including the effects of mutual coupling. The program can cope with arrays of up to 5 × 5 elements. Theoretical work was done by him at UCLA under R.S. Elliott and was published recently at a conference in Italy. At the time of my visit, he was involved in measuring an experimental resonant array made up of 2 similar adjacent waveguides, each with 4 inclined slots.

Orefice is also involved in a feasibility study project for the Italian government concerning an Italian satellite, planned for launching in 1983. The system is intended for TV, telephone, and other point-to-point communications. For other satellite-related work, CESPA has proposed to the European Space Agency (ESA) that it fund a theoretical study of a cosec^2 radiation pattern antenna for a more uniform coverage with a low-orbiting satellite system.

CSELT, also in Turin, is the research institute for a financial-holding-group giant, STET (for historic reasons, STET is the acronym used for Società Finanziaria Telefonica p.A.). STET is one of several similar organizations that have been set up by the Italian government through its institute for industrial reconstruction (IRI). It has a capital of some $500M represented by shares of which the government owns a majority

and the rest are traded on Italian stock exchanges. STET is the controlling shareholder of the Italian telephone company and of other companies involved in various communications businesses: underwater and overland cables, radio relays, and space communications. It also controls major electronic equipment manufacturing companies (e.g., Selenia) where the public also has access to a minority of the shares. CSELT's functions include assistance to those companies that do not have their own research organizations.

At CSELT, I was received by Ing. Salvadore de Padova, division manager, and Dr. Paolo Bielle, who is in charge of the antenna group which has some 10 people. There is much collaboration with Zich from IE&T. One of their main areas of interest has been in satellite communications, ground-based and onboard antennas. They have developed a computer program to give the design of a high-efficiency, low-cross-polarization and low-first-sidelobe reflector antenna for use with a European communications satellite. The primary feed is a corrugated horn which was built to Zich's design and in which excellent experimental agreement with theory was found. Included in the computer program was the procedure for finding the equivalent phase center of the feed.

It should be noted that in Europe there is much preoccupation with polarization which is regarded as one of the most important parameters of a radiation system. In radar, circular polarization is widely exploited for the supression of rain echoes. At Thomson CSF in France they have developed phased arrays with circular polarization for that reason and their technical director claims that it should be the first requirement for any radar. Polarization purity is very important to the new generation of space communication systems since orthogonal circular polarizations are used to permit independent channels which require low crosstalk. A polarization tracking system has therefore been developed at CSELT to maximize channel isolation. The system was originally built for the 4 to 6 GHz band using circular polarization, but tracking is on a linearly-polarized beacon from the satellite.

Satellite communication systems frequently require shaped beams for optimal coverage. De Padova and his team have developed a method of designing offset reflector antennas to give elliptically shaped beams. The reflector has a circular cross-section for easy illumination with a symmetric feed. It is an elliptical paraboloid giving a phase across its aperture that is constant in one plane but has a spherical law in the other plane which in turn leads to beam broadening. The study resulted in design curves and beam contour plots for both aligned and orthogonal polarizations and included the antenna efficiencies.

Turin is an active center for antenna development with both the IE&T and CSELT regularly contributing to the scientific literature. (T.C. Cheston)

COMPONENTS FOR 80-300 GHz—A COLLOQUIUM

A 1-day colloquium entitled "Waveguides and Components for the 80-300 GHz Frequency Range" was held at the Imperial College, London, on 23 April 1981. It was sponsored by Britain's Institution of Electronic and Radio Engineers and chaired jointly by Dr. K.W. Gray (Royal Signals and Radar Establishment, Malvern) and Prof. P.W. Robson (Univ. of Sheffield). About 70 people attended, an indication of considerable activity in that field, and 10 papers were presented.

The first paper, "Waveguide Components and Integrated Subsystem Concepts for the Frequency Range 80-300 GHz," was written by M.W. Boot, M.C. Carter, and E.G. Stevens (EMI Electronics, Wells). For many years EMI has been involved in radar modeling with scaled systems and in millimeter and submillimeter developments for both active and passive components. They mainly use standard waveguide and, using electroforming, have produced a whole range of components, from attenuators to directional couplers, filters, and phaseshifters. They have produced a range of mixers using GaAs Schottky barrier diodes with typical conversion losses of 6 dB at 40 GHz rising to 17 dB at 325 GHz, with a local oscillator power requirement of about 1 mW.

EMI has built a 280 GHz radar system using electroformed microwave components with tolerances tighter than 0.01 millimeter, using machined and polished aluminum mandrils that are etched away after copper has been deposited. Waveguide losses are high, about 0.3 dB/cm. For long runs they sometimes use X-band waveguide.

The EMI researchers also described work at even higher frequencies with a GaAs broadband (500-1000 GHz) mixer which has at this time a conversion loss of 20-30 dB, but they expect to reduce this significantly.

A 693 GHz radar using laser techniques was built, optically pumped, and

a similar system at 288 GHz is now being constructed. A start has been made developing all types of planar technologies for lightweight and compact devices that can be manufactured cheaply in quantity.

"Mixer Developments for Short-Millimetric Waves" was a paper authored by M.J. Sisson, P.M. Wood, and D.G. Monk (GEC Hirst Research Centre, Wembley). It described a new microstrip version of the GaAs beam-lead diode and both good electrical performance and ruggedness was claimed. A low-loss glass wall surrounded the chip and supported the beams, giving strength and reduced capacitance. A pull-strength of 5 g was noted when the diode was bonded into the microwave circuit. A single-ended mixer showed a rectification efficiency of about 0.6 mA/mW at 140 GHz and 1.5 mA/mW at 90 GHz. In the 90 GHz region the conversion loss was less than 7 dB. The diodes were said to be commercially available.

After this paper, as well as after the following two papers, conflicting opinions were expressed by various participants of the meeting. Some believed that different diode constructions including "cat's whiskers" types could show even greater ruggedness and have lower local oscillator power requirements.

In a paper entitled "E-Plane Circuits and Components for Frequencies up to 140 GHz," S.J. Nightingale, R.N. Bates, and M.D. Coleman (Philips Research Laboratories, Redhill) described a variety of E-plane circuits using a PTFE material, reinforced with glass microfibers and metallized with copper. E-plane circuits use a dielectric substrate fixed in the center of a waveguide which carries the various circuit elements. Losses are lower in such circuits than in microstrip circuits but higher than with waveguide. They described components in three bands: 27-40, 60-90, and 90-140 GHz with most of the effort being concentrated in the lower two bands. The authors have built diode mixers, molded in plastic, giving a conversion loss of about 5 dB at 27-40 GHz with a 5 mW local oscillator signal, and deteriorating to no more than 6 dB with a change of the local oscillator contribution down to 0.25 or up to 20 mW. The corresponding figure at 60-90 GHz was given as 8.5 dB. The team has also designed PIN-diode switches and attenuators and has developed a doppler radar using a Gunn-diode oscillator and a radiometer, both operating at 35 GHz.

A further paper discussing mixers was presented by T. Oxley (Marconi Electronics Devices Ltd.), belonging to the same industrial group as GEC, (Hirst), who had also used the planar microstrip beam-lead dieode described by M.J. Sisson, et al. in the second paper. Oxley reported having achieved a 10% bandwidth in the 60-90 GHz band and said that he was presently aiming for 20%. He described a new package that had been developed, made of quartz 500 μm × 740 μm in cross-section and suitable for operation up to 100 GHz. He had also investigated harmonic mixers. He reported conversion losses with beam-lead diodes that were in agreement with those found by the group at GEC Hirst and said that it was not yet known how the final noise figure would change as a function of local oscillator power and that the choice of that parameter should therefore be deferred.

"Microstrip Circulators in the Frequency Band 60-95 GHz" was the title of a paper written by P.M. Brigginshaw and J.E. Curran (GEC Hirst Research Centre) and presented by W. Brown. He remarked that available ferrite material for microstrip 3-port junction circulators at those high frequencies required a much higher value of saturation magnetization ($4\pi M_S$) than was available, and he said that this limited the overall performance. Using a Transtech (Gaithersburg, MD) nickel-ferrite design, curves were obtained giving, for instance, at about 80 GHz, an isolation of 15 dB over a 30% band or 20 dB over a 10% band (cf., 20 dB, 45% at 9 GHz).

Dielectric waveguide developments were described in a paper by R.V. Gelsthorpe and N. Williams (ERA Technology Ltd., Leatherhead). The waveguides were made of a rectangular cross-section dielectric ($\varepsilon = 10$) strip which was laid on the conducting ground plane with or without an intervening thin dielectric ($\varepsilon = 2.5$) sheet. The devices, "Image Line" and "Insular Line" respectively, were quoted as giving lower losses than the E-plane circuits. Various devices were described including ring filters coupled by proximity to input and output lines; radiators formed by protruding the dielectric beyond the ground plane, thus making dielectric rod radiators; and printed antennas produced by covering the line with a slotted conductor. The authors said that thick film printing of the waveguide was being investigated and they stressed the low cost aspects of this technology.

An interesting and novel approach for a low-loss, high-power millimeter-wave transmission line was given in a paper, "Groove-guide and Components for Short Millimeter Wavelength," by D.J. Harris, Y.M. Choi and S. Mak (Dept. of Physics, Electronics, and Electrical

Engineering, Univ. of Wales Institute of Science and Technology [UWIST], Cardiff). The guide was described as being physically large, heavy and very rugged, and without critical tolerances. It consists of two parallel metal plates about 6 wavelengths wide, separated by about one wavelength. Both plates have a longitudinal groove in the center to guide the waves, about one wavelength deep and 1.5 wavelengths wide. Only one mode is propagated along the grooves. The loss is extremely low; at 100 GHz it is in the range of 0.2 dB/m for an aluminum guide and can take peak powers up to about 200 kW. Components such as transitions to standard waveguide, bends, and multi-port hybrids can be fabricated easily, and a "slotted" line for VSWR (Voltage Standing Wave Ratio) measurements can be obtained readily using the space between the plates. Work in progress includes the development of detectors and local oscillators for this medium.

There were two papers from Plessey Research Ltd. (Caswell). The first described studies of relatively low-power local oscillators in which InP was found to be much superior to GaAs at short millimeter wavelengths; over 10 mW has been obtained at 120 GHz. The second paper discussed Si IMPATT oscillators with which it should be possible to develop up to 1 W CW at 100 GHz if thermal limitations can be overcome with better (diamond) heatsinks.

The last paper, by Diane C. Platts (English Electric Valve Co. Ltd., Chelmsford), described a 95 GHz magnetron weighing 1.8 kg and delivering 0.6 W average, 3 kW peak power with 50 ns pulses (4,000 pps). Mechanical tuning is over a 1.5 GHz range.

The meeting was lively and interesting. The absence of papers from government establishments was noted. *(T.C. Cheston)*

MATERIALS SCIENCE

POLYMER SCIENCE IN SOUTHERN GERMANY

The city of Ulm is situated on the banks of the Danube about halfway between Stuttgart and Munich. The University of Ulm is about 5 km outside of the city.

My host in the Department of Experimental Physics was Dr. W. Frank, who described their work on polymers, much of which is on the crystalline structure of linear polymers. Frank specializes in far-infrared spectroscopy, 30 to 500 cm^{-1}, and has studied polyethylene (PE), polyamines, and polyurethanes (PU). In the work on PE, he has mapped the temperature dependence, between 14 K and 400 K, of the adsorption spectra from 50 cm^{-1} to 120 cm^{-1}. The temperature dependence of the principal band ($\sim$70 cm^{-1}), a translational lattice vibration, shows a change in slope at 243 K which he attributes to a change in the mobility of defects at the glass transition of the amorphous portion of this partially crystalline polymer. There are various reports in the literature of a T_g for PE near 240 K. Frank has compared the far-infrared spectra of benzene with those of PU, polystyrene (PS), polycarbonate, and polyethylene terphthalate. All of these polymers have benzene rings in the polymer backbone and, in common with benzene, have an adsorption peak near 100 cm^{-1}. He attributes this peak to a coupled torsional vibration of the aromatic nuclei. In the case of PU, he has been able to relate the intensity of this band (at 96 cm^{-1}) to the number and size of the hard segment clusters (diphenyl-diisocyanate) that form in this copolymer. He has also observed lattice vibration peaks which he attributes to crystal structure in the clusters. Frank is also investigating a series of polyamides (nylons) as models for H-bond bridging in polypeptides and proteins. He has found characteristic features in the far-infrared spectra and has made some tentative assignments as to their molecular origin.

Very recently, Frank has begun to investigate the effects of mechanical stress on the infrared spectra of polymers. He has built a device to strain small samples directly in the spectrometer. However, due to the finite time it takes to obtain a spectrum, the measurement is degraded as the sample undergoes relaxation. He believes the problem can be solved by using Fourier transform infrared spectroscopy.

H.G. Kilian, also in the Department of Experimental Physics, has been deeply involved in the thermodynamics of polymer crystallization. He starts from the premise that crystallization is a segregation process: segregation of chains of different lengths, of chain ends, and of chains having different molecular structures. From this he has developed a theory based on mixed crystal formation. Experimental confirmation is sought from observation of the heat capacity of melting, solvent swelling, and small-angle X-ray spectroscopy. Kilian has obtained satisfactory correlation between his theory and his experimental results. In order to understand

and interpret the relationship between solvent swelling and crystal morphology, Kilian has developed another analysis technique based on cluster network theory. This development is closely related to his earlier work which treats crystal networks in terms of a molecular theory of rubber elasticity.

There are two departments of experimental physics at Ulm: Abteilung für Experimentalphysik (AEP) I and II. Frank and Kilian are in AEP I. Dr. P.C. Hägele is in AEP II and is working on the defect structure of polymer crystals. Specifically, he is studying the effect of defects on skeletal vibrations and the development of theoretical vibrational spectra. Hägele is currently interested in kink defects in PE and PS crystals. Dr. U. Leute, who is also in AEP II, has made extensive measurements on the dilatometric behavior of polymers under pressure—mostly density changes in passing through solid-liquid transitions. Most of this work has been done at pressures up to 8 k bars, but some data were taken at pressures as high as 12 k bars. He has studied PE, polyethylene oxide (PEO), polytetrafluoroethylene, polypropylene, polybutene, and paraffin. From these studies he has found that the pressure dependence of the melting point is a very sensitive function of the molecular weight and he has been able to obtain information about crystal conformation. Recently, Leute has been determining the mechanical relaxation spectra of polymers over wide ranges of frequency (.1 to 36 kHz) and temperature (liquid N_2 to 250°C). This work has included a study of muscle fiber from which Leute concludes that actin molecules are folded but that chains run between crystals. Muscle action involves the folding and unfolding of actin crystallites.

Dr. R. Kimmich heads the Nuclear Magnetic Resonance Section at Ulm and has been investigating relaxation phenomena in polymers. In a theoretical study of PEO melts, he predicted three characteristic motions: anisotropic segment reorientation, reptilation, and fluctuation of the environment around the reptilation tube. Reptilation motion refers to the model in which polymer chains diffuse by a snaking of individual chains through a tube composed of surrounding polymer. The NMR relaxation data obtained by Kimmich support the theory for three-chain motions. Currently, Kimmich is investigating partially deuterated PE which should slow down the reptilation rate and give longer NMR relaxation times.

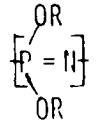
W. Pechold in the Department of General Physics is very highly regarded in the polymer physics community, primarily for his in-depth theory and experimental work on polymer crystal structure. He has provided support for the "meander" or "bundle" model of the crystalline structure of linear polymers originally proposed by V.A. Kargin (*Kolloid-Zh.*, 19 131 [1957]). This model considers that the crystalline structure consists of bundles of parallel molecules that can be folded sharply at crystallite boundaries but that a given chain can belong to a number of adjacent bundles; it meanders. Disorder in the crystalline material is viewed to be largely attributable to kink defects which do not disturb chain parallelism. Pechold has investigated the mechanical and dielectric relaxation of various polyolefins and has shown that the meander model can account for the glass transition and viscoelastic flow relaxations—two essential requirements of any theory of polymer crystals, according to Pechold.

Freiburg is a major commercial center in southwestern Germany, near the Black Forest. The Institute of Macromolecular Chemistry (IMC) at the University of Freiburg is called the "Hermann Staudinger Haus" in honor of the Nobel laureate, for his contributions to polymer rheology.

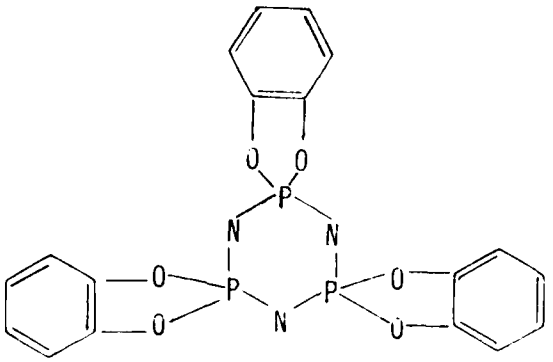
IMC, which was established by Hermann Staudinger about 30 years ago, receives its funding solely from the West German government. It does not work directly for industry although there have been cooperative programs. There are two chairs in macromolecular chemistry, one held by Prof. Dr. H.-J. Cantow and the other by Prof. Dr. G. Wegner.

My host at IMC was Dr. R. Lenz, on sabbatical leave at Freiburg from the University of Massachusetts. During his sabbatical, Lenz is working on the orientation of low-molecular-weight liquid-crystalline polymers in magnetic and electric fields. He is doing this work cooperatively with the Solid State Physics Department at IMC. He is also working with a group in Pisa on transport properties through liquid crystalline membranes.

Another American, Dr. R. Singler, from the Army Metals and Materials Research Center (AMMRC, Watertown, MA) was also on sabbatical leave at the institute. Singler has been working for many years on the synthesis of phosphorous-nitrogen (PN) backbone polymers,



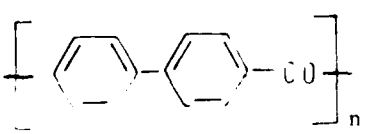
in collaboration with H.R. Allcock (Pennsylvania State Univ.). Recently Singler has been investigating the cyclic PN compounds such as,



which form tunnel clathrate structures. Work at Freiburg has shown that regularly structured polyvinyl chloride can be formed by gas-phase polymerization of vinyl chloride in these tunnel structures. Polyvinyl chloride formed in this way has a very high degree of crystallinity. Wegner has had similar results in synthesizing polybutadiene.

Singler is extending this technique to the synthesis of polymers. In his work at AMMRC and at Freiburg, he has tried polymerizing cyclohexadiene, dimethylbutadiene, and acrylonitrile. He has not been able to obtain polymers from acrylonitrile and the yield from the other two monomers has been rather low. He thinks the problem lies in the method used to recover the polymer from the clathrate, and not in the polymerization itself.

Dr. H.R. Kricheldorf is investigating the synthesis and st acture of some polyesters and polypeptides. He is especially interested in some lactone-based polyesters which are biodegradable. Currently, he is studying the effect of various Lewis acid catalysts (BF_3, $AlCl_3$, etc.) and has evidence of chain extension involving the opening of the lactone. Kricheldorf is also working on aromatic polyesters obtained by Grignard reagents to give polymers with the repeat unit,



which are heat stable up to 430°C in N_2 and to 350°C in air. These polymers are extremely insoluble and infusable and must be dissolved (degraded) in alkaline methyl alcohol to determine their molecular structure.

W. Gronski is using high resolution NMR to characterize the molecular motion of linear polymers in solution, specifically, ethyl vinyl acetate and ethyl vinyl ester. He is able to get accurate relaxation times and thus he obtains good chain sequence resolution. From theoretical models for specific local motions, e.g., jump mechanisms or crankshaft motions, he calculates relaxation times which he compares with experimental results. One of his conclusions is that the simple crankshaft motion is usually not applicable. However, interpretation of the results is complicated by the superposition of chain conformational motion on local segmental motion. Gronski believes the problem can be solved by studying the polymer at various solution concentrations which will systematically reduce configurational motion and reveal local motion. He has, in fact, been able to observe this effect in a study of a copolymer of propylene and 1,4-butadiene with an exactly alternating segment sequence (obtained from Japan).

Dr. W. Burchard has an extensive and intensive research program on branch polymers. Part of the work is rather broadly aimed at the structure of branch polymers—both natural and synthetic—and on their gelation. His principal tool for studying these polymers is quasielastic light scattering which gives information on both translational motion and internal motion (when these motions are large compared to the incident wavelength). In studies of the emulsion polymerization of polyvinyl acetate and polymethylmethacrylate, Burchard has shown that the classic Flory-Stockmayer-Gordon theory of gelation (cascade theory) is not entirely adequate. He thinks that the difficulty is caused by intramolecular interactions leading to ring formations and that some modified form of the theory of percolation (Hammersley, [illegible] 53, 642 [1957]) which deals with ring formation is needed. Burchard's work on biopolymers has been devoted to fibrinogen in which he has shown that in the enzymatic gelation of fibrinogen, the molecules are initially rigid rods which gradually cluster in a random fashion to form an open network until gelation occurs. From light-scattering experiments he has determined that the rods have some flexibility. The extent

of network formation varies according to species and age. In diseased individuals, the amount of network formation is sometimes very small and so, presumably, the strength of the gel (clot) is weak.

Cantow, who holds one of the two chairs in macromolecular chemistry, is very well known for his work on the NMR spectra of polymers, especially at high concentrations (*ESN* 34-2:78 [1980]). Currently he is working on the structure of multicomponent polymers in which one polymer is the backbone which is crosslinked by bridges of the second polymer. These systems differ from conventional block copolymers or interpenetrating network polymers. Using stress-strain measurements and NMR spectroscopy on water-swollen gels, Cantow is determining the conformation of both the backbone chains and the bridging crosslinks. Later work will involve measuring the dynamic mechanical behavior of the hydrogels. Cantow is also involved in a special, government-funded study of cellulose-based block copolymers. The aim of the effort is to develop nonpetroleum-based plastics, but the work is in its very early stages.

As with other polymer research I have seen in West Germany, the work at Ulm and at the IMC is first rate and well funded (by the government). The effort is strongly fundamental with a good mixture of theory and experiment. The ties with industry are much looser than is the case for the Deutsches Kunstoff Institut in Darmstadt (*ESN* 35-3:116 [1981]) or the Institut für Kunststoffverarbeitung (*ESN* 34-5:228 [1980]) in Aachen where there is considerable cooperation with the plastics industry. (Willard D. Bascom)

SURFACE AND POLYMER SCIENCE AT MULHOUSE

During a liaison visit to the Centre de Recherches sur la Physico-Chimie des Surfaces Solides in Mulhouse, France, I was hosted by the center's director, Prof. Dr. J.-B. Donnet, who is widely known for his extensive contributions to surface chemistry. Dr. J. Lahaye, the vice-director of the center, made a valuable contribution at the beginning of the visit by outlining the research activities being carried out by the organization. He explained that 90 percent of the center's funding comes from the government: 80 percent of it from the parent organization, Centre National de la Recherche Scientifique (CNRS), and the rest from other government organizations. Private contracts account for only 10 percent of the center's funding. The staff at the center consists of 40 to 45 professionals with about 20 technicians. Their work is all basic research, but they have considerable contacts with industry which Lahaye feels keeps their programs relevant. Despite these personal contacts and the fact that they present lectures at industrial meetings, they do not specifically direct their efforts to industrial problems.

There is a close connection between the center and the Université des Haute Alsace, which is also located in Mulhouse. In fact, Donnet is president of the university. About 20 graduate students are conducting their PhD thesis work at the center. Three members of the center's staff—Donnet, J. Schultz, and H. Reiss—are also on the university's staff. They are required to teach as well as to conduct research and are paid by the Ministry of Education rather than by CNRS.

The research programs at the center are selected by the staff, but about once a year a Directing Committee conducts a review. The committee is composed of scientists—mostly French, but with some non-French participants. The committee makes suggestions, but the center is not required to comply with those suggestions. Lahaye indicated that the scientific caliber of the committee is generally quite high and its advice is usually sound.

The research is divided into six categories: formation of solids, physical chemistry of carbon surfaces, studies of phyllosilicate minerals, interaction of highly-divided materials, solid/liquid interfaces, and solid/solid interfaces. The work on the formation of solids is directed by Lahaye and largely involves deposition onto solid substrates. In studies of gas phase deposition, Lahaye is principally concerned with carbon deposition onto cold surfaces, e.g., soot and carbon-black formations. He is especially interested in the detection and identification of the particles present in the gas phase. Other aspects of the work involve depositing films on solid particle substrates by ion exchange, mechanical work, or evaporation.

Donnet's work on the physical chemistry of carbon surfaces is extensive and highly regarded. Due to the pressure of his duties as both director of the center and president of the university, much of the work in this area is now directed by Lahaye. Currently the research is on the oxidation processes involved in the formation of carbon fibers, the surface chemistry of such

fibers, and the electrochemical properties of acetylene carbon black.

Dr. B. Siffert directs the study of phyllosilicate minerals. These materials are clays with layered structures and, like graphite, can be intercalated by small molecules (the molecules penetrate between the layers, often forming strong bonds). Siffert is principally interested in the intercalation by surfactants and hydrocarbons as it relates to secondary oil recovery (where surfactant-hydrocarbon suspensions are used to drive residual oil out of sand beds: *ESN* 33-11:457 [1979]). He is also investigating the polymerization of peptides in phyllosilicate clays and trying to determine the catalytic role of the clay surface in these reactions.

Dr. E. Papirer is doing extensive work on the interaction of highly divided materials, both powders and fibers. Much of this work is on chemical modification of the particle and fiber surfaces. For example, he is treating silica particles to create Cl-groups which he then reacts with alkaline salts of n-alkane (C_6-C_{10}) hydrocarbon alcohols. The reaction can be controlled and the resulting surface composition can be characterized quantitatively. The result is an essentially hydrocarbon surface, and Papirer is investigating how a systematic change in chain length affects the wettability of a powder, the entropy and enthalpy of gas absorption, and the degree of orientation. Presently he is investigating chain segment mobility using NMR and he has observed an interesting effect: there is a thermodynamic transition between room temperature and 20 K, possibly a change in the organization of the aligned chains.

Papirer is also looking at the effect of surface modification on the action of silica and carbon black as fillers in elastomers. In the reinforcement of these viscoelastic materials, he finds that chemical bonding of silica to the matrix is not essential. On the other hand, when the filler is carbon black, on the surface of which polymers have been grafted, he finds that for low-strain conditions, the elastomer's stiffness modulus is affected by the chemical interaction between the surface treated filler and the elastomer matrix.

Schultz is directing the research on solid/liquid and solid/solid interactions. With his co-workers, Dr. M. Brendelé and M.E.R. Shanahan, Schultz is studying the environmental cracking of polyethylene at high mechanical stress levels. They have shown that the rate of cracking is largely controlled by the rate at which the attacking liquid can reach the crack tip. Typical stress-cracking liquids are polydimethylsiloxane, paraffin oil, and tricresol phosphate. The principal parameters that determine this cracking rate are the viscosity of the attacking liquid and its spreading pressure on polyethylene (spreading pressure is closely related to wettability). Another factor involved is the extent to which the attacking liquid swells the polyethylene; swelling tends to blunt the crack tip and reduce the rate of cracking. Recently, Schultz has been working in the area of solid/liquid phenomena in a study of the gelation of liquids by high-surface-area solids.

Brendelé is investigating polymerization under high electric field conditions. With one electrode a tungsten (W) wire bent to form a V-shaped tip, and the other electrode a straight wire oriented perpendicular to the first (with a suitable gap between the W-tip and the midpoint of the straight wire), he is observing polymerization in liquid styrene. If the W-tip is positive, cationic polymerization occurs at the straight wire and at a rate determined by the migration time of the charged specie between electrodes. The system must be very dry. If the tip is negatively charged, cationic polymerization occurs at the W-tip, but in this case trace amounts of water must be present.

The work on solid/solid interactions involves lubrication and adhesion. Brendelé is studying the lubricating action of lamellar solids (dry lubricants like graphite). He is grafting polymers onto a lamellar surface in an attempt to reduce friction. Difficulties arise in getting the polymer into the internal lamellar surfaces. One of the effects that he has observed is that the grafted polymer seems to increase rather than decrease friction in the first traverses. Eventually, a transfer film is formed by a process that seems to depend on the surface energetics and the mechanical energy input.

The adhesion studies include surface modification of model fillers, e.g., silica, to enhance filler adhesion to organic polymer matrices. Schultz and Donnet have done work on the surface chemical composition of graphite fibers and its effect on fiber-to-resin adhesion. Shanahan is investigating the creep behavior of lap-shear adhesion joints. Among his findings are that early in the creep history, there is partial debonding along the highly-stressed edges of the bonded area. Thereafter, the stress is more evenly distributed

across the bond and the rate of creep decreases. He has developed a chemical potential argument for a creep rupture threshold, i.e., no creep failure occurs below certain stress levels.

One cannot help but be impressed by the quality of research at the center and also by the enthusiasm and vigor of the staff. By the end of my visit, it had become obvious that Donnet is very much the spark plug of the activity at the center—and no doubt at the university. His enthusiasm and vigor is contagious and it feeds both his staff and students. (Willard D. Bascom)

OCEAN SCIENCES

THE MARINE GEOLOGY DIVISION OF THE ISRAEL GEOLOGICAL SURVEY

Energy is the name of the game in Israel, because that country has no significant internal sources of energy except solar energy and the potential for developing hydroelectric power by channeling Mediterranean Sea water into the Dead Sea, the surface of which is presently 395 m (1296 ft) below sea level. Because of the critical need for petroleum in its highly mechanized agricultural program and the fact that the Arabs control much of the world's oil reserves, Israel has an intensive search underway for evidence of oil in the waters off its coastline.

There is a team of six scientists in the Marine Geology Division of the Geological Survey of the Ministry of Energy and Infrastructure. Much of the research carried on by this team is related to the energy needs of the country. Dr. David Neev, the head of the team, is carrying out a systematic study of the geology and geophysics of the continental shelf and slope in the Mediterranean Sea to the west of Israel. His studies show that there are offshore oil prospects extending from the coast out to depths of about 900 m. According to his colleague, Dr. John Hall, the most interesting structures that could contain oil are found in depths of 700 m or more, on the slope rather than the shelf. The technology needed to drill and deliver oil from these depths has already been developed, but it is still in the experimental stage and on the edge of being economic at the present time. The big problem is that detailed bathymetric surveys of the slope indicate that bottom sediments are unstable and that major slumping has ocurred. There are also several major fault lines crossing the area.

Neev has also specialized in the tectonic evolution of the Middle East and the easternmost Mediterranean Sea. Egypt, the Sinai Peninsula, Israel, Jordan, and the nearby sea floor is riddled with fault lines and other structures that are evidence of differential movements. He is a prolific researcher and writer, and has published on a wide variety of geological topics.

Hall, who was educated at Scripps Institution of Oceanography, is a specialist in seismic studies of the ocean floor and of sediments below the floor. At the present time, he is compiling a very accurate chart of bathymetry of the southeastern Mediterranean Sea extending from the coast of Israel to 28°W longitude, the longitude of the Isle of Rhodes. He is working with 150,000 km of track line. Now he is archiving all of the available geophysical data for the same area and correcting geophysical data tracklines for navigational errors by matching their bathymetry to that on his master bathymetric charts. His end products will be a set of gravity, magnetic, and seismic survey charts of the area. There are sufficient seismic data available to determine the three-dimensional structure of the sea floor.

Hall has also done shallow seismic-survey work on Israel's continental shelf area in an endeavor to discover and inventory potential sources of aggregate that could be mined for construction purposes. He found that most of the sediments were too consolidated for economical recovery. Hall and his assistant recently made the first detailed bathymetric survey of the Gulf of Elat and published a beautiful bathymetric chart of the Gulf.

Dr. Gideon Almagor is a geologist-geotechnologist. Most of his work has been concerned with the physical (engineering) characteristics of marine and coastal sediments, soil mechanics, coastal preservation, and sediment transport along the coast. Much of the coast of Israel is tectonically very active. Recent deposits of marine shells have been found at elevations up to 40 m above sea level. In several locations, these beds overlie ancient sites dating from the time of the Roman conquests to the period of the Crusades. Moreover, undisturbed Roman masonry (dating to about 10 B.C.) with lead-cast joints has been found in situ more than 10 m below sea level, giving evidence of the subsidence of an ancient harbour by at least 10 to 15 m. These indications of very large vertical movements of land near the shoreline in historical times are well documented.

Thus it is undesirable, for both engineering and safety reasons, to place large, heavy structures near the edge of the water. However, this is where developers have placed big, heavy power plants that use seawater for cooling purposes, and where they now desire to place more such structures. Some of the proposed plants will be coal fired; others will operate on nuclear power. Neev's group has already blocked the placement of one nuclear power plant that was scheduled to be built right on the shoreline. Neev believes that some of the tectonic movement is related to a presumed fault line that lies very close to shore. I was told that some geologists believe differential vertical earth movements near shore could break cooling water intakes which in turn could increase the possibility of a nuclear-power-plant meltdown.

Almagor has documented the fact that there has been considerable slumping of sediments offshore from Israel. Bathymetric contours clearly show evidence of large slumps several kilometers wide and up to 5 or 6 km long. These slump scars are located near the break in the shelf and extend down the continental shelf. They are of interest because they are at or near areas where there may be oil deposits. Almagor believes that the slumps resulted from occasional small earthquakes that caused an accumulation of instability until a subsequent earthquake triggered a slump.

Almost every laboratory that I visited in Israel was carrying out research on the Dead Sea to present data that will be used in the decision-making process as to whether or not Mediterranean Sea water should be channeled into the Dead Sea to generate electric power, and to determine the volume of water that could be used safely each year.

Neev and Hall have made extensive geophysical and historical climatological studies of the Dead Sea. They made the first detailed bathymetric survey of the sea since an American Naval officer made a bathymetric survey in 1848. Along with the bathymetric survey, they made continuous magnetic and seismic surveys along 540 km of track lines in the Dead Sea in order to study the earth's structure beneath the sea. They have studied climatic changes during the Holocene Epoch as reflected in changes in the area of the Dead Sea and have found that the area of that body of water ranged from three times its present size during a pluvial period to zero during a dry period. In most recent times, the level has declined due to the almost total diversion of its main source of fresh water, the Jordan River, for agricultural purposes.

Another staff member, Dr. Yitzhak Levi is a geochemist and sedimentologist. At present he is carrying out an intensive study of recent processes in the Dead Sea and coordinating the studies of other scientists working on Dead Sea subjects on behalf of the Ministry of Energy and Infrastructure. Previously he had carried out economic studies of the marine aggregate industry while working for the Ministry of the Treasury. He has also spent a good deal of time studying the geochemistry and sedimentology of Bardawil Lagoon on the north coast of the Sinai Peninsula.

Mr. Yaacou Nir is a sedimentologist who is presently studying coast processes along the Mediterranean coastline of Israel and is involved in coastal protection problems both there and in Israel's other coastlines. After Israel assumed control of the Sinai Peninsula, Nir made a geological survey of many of its bays and some of its coastline.

The sixth member of the Division, Mr. Nathan Bakler, a stratigrapher, is presently vice director of the Geological Survey. He has studied the quaternary stratigraphy both in the offshore (shelf) and onshore coastal plain. One of the topics that piques the scientific curiosity of the division staff is related to the Nile River, which in times past supplied most of the sediments off the Israeli coast. Now that its annual cycle has been completely altered by the construction of the Aswan High Dam and the annual silt-laden floods no longer occur, the delta of the Nile is receding and little new silt is coming out of the river. They would like to find answers as to what the new equilibrium will be when the Nile settles down to a steady state, and to determine whether there will by any deleterious effects to the Israeli coastline. (Wayne V. Burt, Oregon State University)

OPERATIONS RESEARCH

OPERATIONS RESEARCH AT SWISS SCHOOLS—PART II, UNIVERSITIES

This article describes operations research (OR) activities at a Swiss school of administration and at 4 of Switzerland's 7 universities. Little or no OR is taught at Switzerland's other universities (the Universities of Zürich, Lausanne and Basel).

St. Gallen

Since the institution of higher education in the small canton of St. Gallen has only a single faculty, it

is technically not a university. As indicated in Part I, this Faculty of Administration has an active OR department. As usual, the department has only a single professor; it has 4 other staff members, 3 of whom have rank equivalent to that of assistant professor. There are also other technical chairs in the faculty, including one in mathematics and statistics, one in econometrics, and two in informatics. The professor of operations research is Paul Stähly, who has studied at the University of Basel, at the Vienna Institute of Technology, and at St. Gallen, where he received the doctorate in 1964 and the habilitation in 1970. He has held the chair since it was first created in 1972; he was also a visiting professor in Linz, a nearby city in Austria, for several years during the late 1970s.

Much of the research in this department follows Stähly's basic interest in simulation. For example, Klaus-Heinrich Edl received a doctorate 4 years ago under Stähly; his research considered methods of optimizing simulation experiments. He is now working on his habilitation with what he calls a methods-based system for forecasting, analagous, he told me, to a "data-base system for data." He has a pool of forecasting systems programmed on St. Gallen's IBM 370/168, from elementary least-squares methods up to rather sophisticated ARIMA and Kalman models. For a given time series, forecasts are made with some or all of the models, and then the different forecasts are compared and various tests applied to see which is stable, and the like.

Another recent doctoral investigation involved a simulation of accidents and other medical emergencies such as heart attacks, with the objective of maximizing the survival rate. The simulation was very wide-ranging, including a determination of where hospitals should be built, how many there should be, how big they should be, whether existing hospitals should be enlarged, whether they should be specialized, what differences (if any) there should be in the manning of emergency rooms during day and night, and where ambulances should be located.

All of the above research has been paid for by the Swiss government through various foundations, but the major efforts now and for the foreseeable future are related to military questions. They have just completed a major simulat on of mobilization. Virtually every able-bodied male in Switzerland is part of the militia, and Switzerland is prepared to mobilize 650,000 men (out of a total Swiss population of both sexes and all ages of only 6,300,000) very quickly. (An additional 450,000, including women and older men, will go into the Civil Defense force.) This is obviously a major endeavor with dramatic logistic implications. While the techniques of the mobilization itself appear now to have been sorted out, the effects on the Swiss economy of suddenly reducing its work force by such a magnitude are still under investigation. As indicated in another article (ESN 35-4: 166 [1981]), Stähly's group is also building models of the overall Swiss economy which will be utilized to coordinate various studies of how Switzerland will manage its energy, food, and the like during wartime or other crises.

Freiburg (or Fribourg)

Since this canton is bilingual, as indicated by its two different spellings, the university is also bilingual, although any particular course is given either entirely in German or entirely in French. In the university as a whole, with 4,000 students, there are slightly more classes in French than in German; but in the economics faculty, with some 600 students, about equal numbers of courses are given in each of the 2 languages. The Institute for Automation and Operation Research is a part of that faculty, and has two chairs: one occupied by the director, Jürg Kohlas, and the other by Richard Kühn. Kohlas took his doctorate at Zürich in mathematics in 1967 and a habilitation in 1972, and was called to Freiburg to take the new chair in OR there in 1974. Much of his own research centers around military OR, about which he would tell me only that he was interested in the simulation of air combat. The fascinating research of his assistant and former doctoral student, G. Egli, is described in a separate article (ESN 35-4: 166 [1981]).

Kühn studied economics at Bonn in Germany, then took his doctorate in marketing in Bern in 1967; after a postgraduate year at Arizona State University, he eventually received a habilitation in 1978, also in Bern. He took a chair at Freiburg in 1979, "to bridge the gap between OR and applications to business," he told me. He had had a good deal of practical experience with business consultation in planning and marketing while at Bern. His research is based on some interesting ideas connected with early warning systems for both tactical management control and strategic decision making. Top managers normally monitor profits as the principal indicator of success, while marketing managers

usually follow such indicators as market share, costs, total sales, sales per product, sales per region, etc.; but all of these discover problems much too late. Kühn is seeking indicators which are more responsive because they are more closely related to causes: such things as the behavior of competition, various environmental trends, changes in retail trends, or changes in the behavior of consumers. Since such indicators are not independent, it is necessary to give attention to what Kühn calls "scenarios of indicators." A change in the pricing policy of a competing manufacturer, in the stocking policy of the wholesaler, or in the buying policy of consumers may be much more dangerous in some contexts than in others. At the present time he has some ideas about significant scenarios of indicators which he plans to publish in *Long-Range Planning*; he is looking ultimately for general methods for determining such indicators and monitoring them, and when he has significant achievement along these lines, he plans to publish in some such journal as *Management Science*. "The idea," he told me, "is not to improve forecasting, but to develop early warning—especially earlier than our competitor—in order to know when the forecast is wrong."

Geneva

The University of Geneva has some 9,000 students in 7 faculties. The computer science department at this university was discussed in a previous article (*ESN* 34-5:179 [1981]). In the Faculty of Economics and Social Sciences, which has about 1,000 students, there are some mathematical statisticians in the Econometrics Department, but they do not seem to do much operations research. What little OR is done is done in the Business Department, the largest department in the faculty, by Profs. Alain Schärlig and André Bender.

Shärlig took his doctorate at Dijon (France) in economics in 1969 with a thesis entitled "Optimum Location and the Theory of Graphs." It was highly theoretical, but he has been moving away from theory ever since. In 1973 he published a book in French entitled *Where to Construct the Factory?* which was a mixture of theory and practice. The section on muticriteria decision-making (MCDM), he told me, was quite thin—whereas if he redid the book now, it would be by far the thickest part. More recently, in completing his movement away from theory, he has run symposia in Basel, where there have been presentations by large firms on "how we located our last plant."

At one time, Shärlig was a science commentator on Swiss TV and was extremely well known to the public. He still considers himself as much a journalist as a scientist. He continues, for example, to be interested in MCDM as applied to location problems, and is writing a book on MCDM which contains absolutely no formal mathematics. His recent doctoral students have written theses on such topics as the influence of autoroutes (a European word for what are called superhighways in America), on the location of industries, and on "urban location," meaning the way people choose where to live within a city.

Bender took an MBA at the University of Kansas in 1968 and then a doctorate at the University of Geneva in finance in 1972, with a thesis on the quantitative analysis of leasing. He is interested in portfolio management and plans to write a book in French on this topic. He feels that the classical methods of financial evaluation of investments in terms of such things as discounted cash flows are now meaningless because of inflation (Switzerland is suffering the "terrible" inflation rate of 5%!) and the fluctuation of interest rates. He is also interested in recommending changes to the Swiss law which forbids the managers of pension funds to buy any equities, or in fact any investment other than bonds. There are "mountains of money" in these funds, and because the inflation rate exceeds the interest rate on the bonds, they are losing real money.

Bern

The University of Bern has 6,000 students, of whom the Faculty of Business Administration has 500. There are 12 chairs in this faculty, 7 in economics and 5 in business administration. Of these 5, one is occupied by Werner Popp, professor of operations research. He took his diploma in economics at the University of Munich and his doctorate in applied statistics at that university in 1960. After postdoctoral work in the mathematics of OR in Zürich, he became a professor at the University of Mannheim (Germany) while, at the same time, carrying on a consulting business in Zürich. Since 1973 he has been a professor at the University of Bern, although he still lives in Zürich. He now has a research staff of 9, of whom 3 are paid by the university, 3 by the federal government, and 3 by private institutions on consulting work. One of these 9 already has the doctorate and most of the others are doctoral candidates.

I talked to one of these doctoral candidates, H. Vollert, who took his diploma in mathematics at the University of Erlangen and Nürnberg. He is working on the problem of distributing blood from a single regional depot to 20-40 hospitals. Any blood which is not used before it is 21 days old must be discarded; the objective is to minimize the amount of blood lost in this way. In fact, in the past, a considerable amount has been lost; this is a very sensitive subject, because blood is given by volunteers who are likely to refuse to give it if they feel it might be lost through mismanagement. The problem is not a new one, and some solutions have been proposed in the United States, but Vollert's analytic model is somewhat different, having no Markov chains; in addition, he has an elaborate simulation model. Vollert and Popp explained to me that the problem was to find a decentralized solution. The Swiss are highly individualistic and do not like centralized control. Vollert's simulation model, for a planning horizon of 2 years, takes several minutes to complete each run on an IBM 3033 computer. (I was amused to note that he did not know exactly how much CPU time each run took. Apparently he does not have to pay for the computer time, which is supplied free by the university.)

Popp has a speciality: he forecasts the space requirements and sales of new department stores in Switzerland and Germany. He appears to be extraordinarily good at this. He has done this type of forecasting 5 times, and has yet to make an error in prediction as great as 5%. His model, for example, assumes that the probability that an individual will shop at a given store is an exponential function of that person's "distance" from that store, where distance is measured by the time it takes to get there and is therefore strongly affected by such things as the existence of public transportation. If there is a competing store, a boundary is drawn between the two stores and it is assumed that people go to the store on their side of the boundary. If one store is more "powerful" than the other (a word which he used, apparently, to describe its attractiveness or marketing effort), the boundary is moved appropriately. Finally the model depends upon such things as the income of the individual, marital status, the number of children, and other such data which can be obtained from the census and similar sources.

Popp's most recent interests are in strategic planning. As with the OR departments in so many other Swiss universities, his research is heavily subsidized by local industry.

Neuchâtel

Neuchâtel's university has only 3 faculties, one of which is law and economics. Within this faculty there is a "group of research in quantitative methods" of which the director is Prof. Alfred Strohmeier. Although he is a German Swiss who did his undergraduate work at Basel, Strohmeier not untypically went to Paris to the Sorbonne (which, after the troubles of 1968, became Paris VI). There he took a master's degree in mathematics and a doctorate in optimal control in 1971. He came to Neuchâtel in 1972 as the first instructor in operations research. He now has a chair. The only other related chairs in the university are one in statistics and a half-time chair in computer science. He has 4 teaching assistants paid by the university and 3 assistants paid by research funds.

Strohmeier emphasized that most of his group's OR work was in the intersection between OR and statistics or between OR and computer science. As an example of the latter, he mentioned a language being developed for manipulation of graphs, and in particular of those graphs which arise from the analysis of natural speech (in either French or English), used ultimately to point the way toward automatic speech recognition. He also indicated that they did consulting on such things as production planning for all of the local industries, including a watch manufacturer, a cigarette manufacturer, and a metallurgical plant. For the latter, there was a problem of assigning particular articles of impure gold to individual machines whose output was pure gold, and also some silver, separated from alloying materials. This assignment problem was modeled as an integer programming problem, and its solution is now being routinely implemented at that plant.

Operations research is extremely active in Switzerland. For a country of such small size, it is remarkable that there are 350 members in the Swiss OR Society (known as SVOR, for Schweizerische Vereinigung für Operations Research, or ASRO, for Association Suisse de Recherche Opérationnelle). Most of these members are academics, because there are comparatively few industrial OR groups in Switzerland. The group at Ciba-Geigy is described in a separate

article (*ESN* 35-3:127 [1981]). There are also OR groups in Hoffman-La Roche, another drug firm; in Nestlé, the famous manufacturer of food products; in Sandoz; in Brown-Boveri; in the Swiss national railroad; in the military; and in Swiss Air. This is a comparatively small number of operations research groups in industry. What is apparently different about Switzerland is that each of its many academic OR groups is not only very practically oriented but also heavily involved in consulting for industry. Remarkably, most of the money that comes in from this consulting is used not to supplement the earnings of the professors (as is common in America) so much as to support the doctoral students and research staff at the university. On the whole, Swiss operations research, like everything else in Switzerland, seems to be extraordinarily competent. (Robert E. Machol)

OPERATIONS RESEARCH IN PORTUGAL

Portugal is a small country, extending 250 km from east to west and 600 km from north to south, with only 9 million people. It is a poor country; while not technically one of the LDCs (less-developed countries), it has one of the lowest per-capita incomes in Europe.

During the period when operations research (OR) was first being tried in most of the countries of Europe, in the 1960s, it was virtually unheard of in Portugal. About a half a dozen years ago, however, the country began making a significant effort to develop an OR capability, sending many students to foreign universities, mostly in the US and Great Britain, for graduate study, and then starting OR programs at Portuguese universities. Until 1974 there were only 5 universities in Portugal, 3 of them in Lisbon, 1 in Oporto, Portugal's second largest city, some 300 km north of Lisbon, and 1 in Coimbra, halfway between Oporto and Lisbon. Other than the Catholic University of Lisbon, all of the Portuguese universities are supported by the state.

In 1974, V. Simão, who was then the Minister of Education, took steps to create four new universities, one in Lisbon and the others in smaller cities throughout Portugal. At about the same time, most of the faculty members from the universities in Mozambique and Angola emigrated to Portugal because of the changing political situation in Portuguese-speaking Africa. These new Portuguese universities are to a considerable extent staffed by such expatriates, plus the younger men who have recently received their doctoral degrees from foreign universities. Several of these universities now have significant programs in operations research and related subjects, and an operations research community is beginning to exist in the country. The leader of this community is Luis Valadares Tavares of the Technical University of Lisbon. He has recently organized the Portuguese Society of Operational Research (APDIO - Associacão Portuguesa para o Desenvolvimento da Investigacão Operacional) of which he is at the moment the leader and which will soon be applying for affiliation with the International Federation of Operational Research Societies. There are as yet virtually no significant OR groups in industry or government in Portugal, and most of the good operations research work being done in the whole country is being done under the direction of Valadares Tavares at the Center of Systems and Urban and Regional Problems (CESUR) of the Technical University of Lisbon.

Valadares Tavares took his MSc in Lancaster (UK) in 1970 and a doctorate at the Technical University of Lisbon in 1974 in the department of civil engineering, writing an OR-related thesis entitled "Systems Analysis on Water Resources." He received the postdoctoral degree of "aggregation" in 1978, and in 1979 was appointed to a new chair in operations research in the Department of Systems Analysis and Urban Planning. Prof. Manuel L. da Costa Lobo also holds a chair in this department. He is discussed later in this article. There is a staff of 20 in the department, all of whom have at least one graduate degree from a foreign university. In most cases, these degrees were received in the UK. Most of the staff are doing applied research in OR; since there are essentially no research grants at this time in Portugal, this means that they are working for industrial and governmental clients.

This is not to say that they are not capable of highly sophisticated work. For example, in attempting to predict the prices and demands for edible oils they acquired a large amount of data on the histories of these prices and demands. They discovered that the appropriate time series had been generated by a non-Gaussian process, and they proceeded to analyze and describe this process and then to publish in the *Journal of Applied Probability* a description of the exponential Markovian stationary process. This new process has application not only to the edible oils, but also to other time series.

The interest in edible oils arose because the Portuguese Government had been subsidizing such oils for the reason that they were essential in the diet of the poorer people. It turned out that imported oils, such as cotton, peanut, and soy oils, were less expensive than the domestically produced olive oil, with the result that the government found itself subsidizing imports which were in direct competition with materials produced domestically. The government then turned to CESUR for help, and Valadares Tavares and his coworkers solved the problem. The result, a strategic model for determining when and how the government should intervene in the oil market, has recently been published in the *Journal of the Operational Research Society*.

CESUR also works for EDP, the electric power utility of Portugal, on several projects. One is the development of a statistical model of the behavior of thermal power stations, the model to be used especially to predict the reliability of such stations. Using simulations, they have aided in the design of new stations and determined the effects of station failures. They have also used standard forecasting techniques to help predict the water inflows to hydroelectric power stations, which produce a considerable fraction of the total electric power in Portugal. Finally, they have been working on computer control of the interconnected electric power system of all of Portugal. In the US, the comparable control is now generally done by digital computers, but Portugal has some special constraints which required that they develop new control algorithms. For example, the correlation of the different water flows to the numerous hydroelectric power stations means that the independence which is often assumed in, say, American power stations is not valid. CESUR researchers have developed a dynamic programming model to take care of this, with an ingenious new approach in which the state variable, instead of being the volume of water in storage at time t, is the expected inflow at time t+1. Using this form of state variable leads to a rather neat form of optimal policy.

CESUR has been doing a lot of work for LISNAVE, a shipyard in Lisbon which is the largest repair shipyard in the world. One of the special projects at LISNAVE was to determine the appropriate inventory-control model for slow-moving items, particulary those which are demanded on an average of less than once per year. The choice is binary: whether to keep in inventory a single such item or none. If one keeps zero items in inventory, then when the demand occurs, it is possible to send a special plane to the source of supply (typically in Switzerland) to pick up the necessary product. This entails a certain easily estimated cost, but no penalty for delay. If one keeps a single item in inventory, then there is a certain cost for holding that inventory in terms of capital tied up, storage costs, insurance, etc. When looked at this way, it is easy to see that if one knows how often on the average the item is demanded, the calculation of the relative costs for 0 or 1 in inventory is straightforward; for example, if it costs $1,000 to get the item, and $50 per month to hold one in inventory, one should be held if and only if it is demanded on the average more than once every 20 months.

Another important client of CESUR is the Portuguese Air Force. The staff of the Department of Systems Analysis and Urban Planning has given courses on OR to high-level officers of the Air Force, who were found very receptive. CESUR staff members are doing activities programming and making inventory-control and other studies for the Portuguese Air Force factory in Alverca, a large plant which maintains aircraft not only for the Portuguese Air Force but also for those of Mozambique and Angola.

Prof. Manuel L. da Costa Lobo, mentioned earlier, took the doctorate in civil engineering in Oporto, and then became interested in urban planning, which he studied at University College in London many years ago. He was studying traffic patterns in two cities north of London, Stevenage and Harlow. Each had bicycle paths. In Stevenage these paths were used, but in Harlow, the cyclists did not use the paths; rather, they stayed on the main roads where they interfered with the automotive traffic. Costa Lobo discovered that the reason was that the cyclists optimized: in Stevenage, the engineers who had laid out the paths had laid them out in such a way that they aided the cyclists in getting where they were going; in Harlow they had simply laid out a path and labeled it "cycle path," but the cyclists discovered that they could get where they were going more rapidly by using the automobile roads. While Costa Lobo had not heard of OR at that time, his analysis was OR; he has since learned a good deal about this discipline, and now leads a large OR team in CESUR, including a number of architects, studying the renewal of central Lisbon, under sponsorship of the municipality of Lisbon.

In another project, sponsored by the Ministry of Public Works, he and his group are planning the appropriate development of the region around the town of Vendas Novas.

At the Classical University of Lisbon and at the University of Coimbra, there are some mathematicians working on operations research, but no applied work is being done at this time. At the New University of Lisbon there is a Department of Informatics (computer science) headed by Alexandre Cerveira, where some OR-related work is going on. This university has had considerable growing pains. It graduated its first students in 1980. There are now some 2,000 students in 4 faculties. The Faculty of Science and Technology has 600 students, but as yet it has no building. The staff in this faculty is 200, creating an extraordinary student/instructor ratio, but because they do not yet have a building, there simply is no place to put additional students. This should create considerable opportunities for research for the younger faculty, but in fact less research is being done than one might anticipate.

Cerveira, who took the doctorate in electrical engineering at the University of Colorado in 1960 and who was a professor in Angola until 1975, is interested in "local networks," that is, networks of computers which are all placed in one building so that they can be conveniently connected by cables. This has led him to an interest in queueing theory, which of course is claimed now by OR people as part of their territory. Typical projects in the department, however, tend to be hardware related; for example, the development of new raster displays which are microprocessor controlled, and optimizing the communications between two such microprocessors. Cerveira was quite proud of the fact that this development had been picked up by a Portuguese manufacturer of computer terminals, which is the nearest thing Portugal has at this time to a computer industry. Several people in the department are also working on the methodology of designing LSI (large-scale integrated) circuit chips.

The University of Oporto has been in existence for more than 100 years. It was originally in the center of the city. A new campus was built a little farther out in 1930, but this campus has also been enveloped by urban sprawl and new buildings are being built still farther out. OR is taught, to all engineering students, in the Mechanical Engineering department, whose head is Prof. Vasco da Sá. The department has sent 3 of its instructors to England for doctorates in OR and expects to start a significant research program as well as an instructional program when they return, but at the present time no research in OR is being done.

A new institute is being set up in Oporto (by the same V. Simão, mentioned earlier, who is now with the Ministry of Industry). Scheduled to start in a couple of years, it will be called the Institute of Management Science. It will have its own staff (paid by the Ministry of Industry), plus staff from the university (paid by the Ministry of Education). The institute will specialize in post-experience courses in OR. Again, this is all in the future. "There is a huge market for OR in public services and in private concerns in Portugal," Sá told me, "but very little is now happening."

The University of Minho in Braga, 50 km north of Oporto, has an active OR program in the "pedogogical unit" (translation: faculty or school) of engineering and in the "area" (translation: department) of production and systems. The head of this area is Prof. Machado dos Santos, an electrical engineer with a PhD in automatic control and digital simulation from the Institute of Science and Technology in Manchester, England. The courses in OR are being taught by Profs. Virgilio A.P. Machado and António Guimarães Rodrigues, who recently completed their doctorates at the University of Florida (Gainesville) and the University of Birmingham (England) respectively. However, Machado has accepted a position at the new University of Lisbon effective next year, and Rodrigues is virtually alone in attempting to get research projects started. His most active project at the moment, in addition to some work on developing programming languages (which is a continuation of his doctoral thesis), is a bibliographic and generalized OR research project in which he is trying to find out what sort of systems exist for production control, and to develop models which can be implemented on microcomputers for application to local industry. They actually have programs already written for accounting, salary processing, and some inventory control, and they are moving on to production control. Rodrigues emphasized to me again the tremendous demand for these types of programs in Portuguese industry. In the region of Minho, the principal industry is textiles; Rodrigues and a colleague, Prof. V. Freitas, have

been working on the development of models for on-line microprocessor control of the energy used in local textile factories. Freitas, who took his doctorate at the Institute of Science and Technology in Manchester (UK) in automatic control, is in a different department, but works with Rodrigues through a research "center" which takes people from a number of departments.

In summary, what operations research there is in Portugal is led by an extraordinarily dynamic young man, Luis Valadares Tavares; but outside of his department at the Technical University of Lisbon, OR in Portugal is not yet well developed. However, there is tremendous enthusiasm, ambition, and capability, and it seems clear that the operations research scene in Portugal in a few years will more closely resemble that of other European countries with comparable resources. (Robert E. Machol)

PHYSICS

A VISIT TO ISRAEL - PART I - BAR ILAN UNIVERSITY

A liaison trip was made to Israel during which several universities were visited. Impressions of these institutions are given in a multiple-part report. This first section deals with Bar Ilan University which is located in Ramat Gan, a suburb of Tel Aviv. The university was founded 25 years ago as an orthodox religious institution. Currently the school has approximately 7000 students.

Studies of the electrical conductivity and related properties of amorphous semiconductors, solid polymers, and dielectric solids are being carried out by Prof. V. Halpern in the Department of Physics. Experiments by Halpern and his colleagues on doped polymers such as polystyrene and polyparaphenylene show that, when suitable dopants are introduced, the electrical conductivity is increased by several orders of magnitude. Contact resistance is a continuing problem in this work and Halpern hopes to have definitive results in several years.

In addition to his academic duties, Halpern is the current secretary of the Israel Physical Society which was founded in the 1950s and has a current membership of 350-400. These relatively few members are organized in a single group whose main activity is an annual 2-day meeting traditionally held in March or April. The 1980 meeting, held 9-10 April at the Weizmann Institute for Science, consisted of 2 plenary sessions and 132 papers arranged in a minimum of 5 parallel sessions. The Bulletin of the Society containing the programs and abstracts of these meetings and the Annals of the Society are published yearly in English. The society is supported by individual memberships and by contributions from universities and research establishments.

For the last 10 years, considerable interest has been generated by the purple patches (the purple membrane) which appear when the bacterium Halobacterium halobium is grown under certain conditions. These purple patches contain 2-dimensional crystalline array of a protein called bacteriorhodopsin because of similarities with visual pigments. This material is an energy converter that acts as a light-driven proton pump whose mechanism is a problem of fundamental importance in biology. Dr. R. Ehrenberg spent a postdoctoral period at Cornell University where his work along with others on resonance Raman spectroscopy of both deuterated and nondeuterated material showed a shift which has been interpreted as evidence that the Schiff base proton in bacteriorhodopsin is strongly hydrogen bonded (*Proc. Nat. Acad. Sci.* 77, 6571 [1980]).

In mid-1979 Ehrenberg returned to Israel from his post doctoral position at Cornell and began the establishment of a laboratory at Bar-Ilan University. He is continuing his biophysical experiments by beginning measurements on membrane potentials by optical techniques. Although these potentials are small (1 ev), they produce a large field across a thin (50 Å) membrane. Ehrenberg is trying to develop a simple and easy measurement method by adding dyes to the membrane and measuring the Raman spectrum of the dye molecules which is affected by the electric field. The first experiments are being made on artificial membranes formed by ultrasonically irradiated lipids and using cyanine dyes.

Dr. I. Laulicht has long been active in various types of spectroscopy. A recent study was of hydrogen in $BaTiO_3$ (*Solid State Comm.* 32, 771 [1979]) in which the absorption spectrum of OH^- impurities was measured in the 2.8 μm region for different polarizations and for temperatures above and below the ferroelectric phase transition temperature, Tc. The spectrum is weakly dependent on temperature up to Tc where the

principal line broadens and the side bands, interpreted as combinations of stretching and translational modes, vanish.

More recently, Laulicht has begun experiments on the fluorescent properties of the stoichiometric rare earth compounds of the NdP_5O_{14} type, which are suitable materials for small lasers. Stoichiometric crystals are expected to have relatively few ionic sites which are not equivalent but there is some evidence to the contrary. Laulicht plans to use Eu^{+3} as a probe in time-resolved excitation spectroscopy to clarify this question and to investigate the dynamics of how the non-equivalent sites participate in energy exchange. Additionally, previously unseen lines are expected to emerge. In preliminary experiments on EuP_5O_{14}, the lines from the $^5D_1$ - $^7F_4$ transition which are weak and usually masked by others have been observed.

Conductivity measurements are being carried out by an immigrant from the US, Prof. A.J. Greenfield, who in 1978 developed a new method for measuring the thermal conductivity κ (*Rev. Sci. Instr.* 49 1533 [1978]). The heat supplied to one end of a rod of the material to be measured travels down the rod and is transferred by radiation to a constant temperature enclosure. In the steady state, the conducted power is equal to the radiated power and a temperature profile is established along the rod. The thermal conductivity κ is determined for the entire temperature range by finding the derivative of the temperature distribution at a particular point and using the remainder of the distribution to calculate the integral which gives the amount of heat radiated from the remainder of the sample. Using an infrared microscope with a sensitivity of better than +.05°C at temperatures above 100°C, the method gives results of +1% for κ.

This apparatus has been used to measure the thermal conductivity of both solid and liquid In in a temperature range of approximately 50 K above and below the melting point of 429.6 K (*J. Phys. F: Metal. Phys.* 10 L95 [1980]). The results are claimed to be accurate to +1% and show a temperature dependence, $\kappa(T)$, in both the liquid and solid phases, but in opposite directions. At the melting point $\kappa(T)$ changes discontinuously by a factor of almost 2.

Combining these results with measurements of the electrical conductivity $\sigma(T)$ gives the experimental Lorenz number $L_x = \kappa/T\sigma$ which, within the limits of experimental error, is found to be temperature independent for both the solid and the liquid phases and with no discontinuity at the melting point. The value of L_x is approximately 9% higher than the theoretical Lorenz number Lo $Lo = (\pi^2/3)\,(k_B/e)^2$ derived on the basis that the relaxation times are identical for electrical and thermal processes. The fact that Lo and L_x are different in both phases may mean that the reason for the difference is an electron-electron effect rather than one connected with the lattice. In order to determine if these results are characteristic of other metals, Greenfield and his students are continuing this type of experiment, working next with Sn.

Low-temperature resistivity measurements on K and Na were reported in late 1979 by Greenfield and his colleagues (*Phys. Rev. Lett.* 43 1822 [1979]). These data were fitted by a temperature dependent resistivity of the form $\rho = \rho_0 + AT^2$ where ρ_0 was the residual resistivity and A was a constant, both of which varied from sample to sample. Further analysis and experiments showed that if the residual resistivity were assumed to be the sum of a part ρ_i resulting from impurity scattering and a part ρ_d resulting from scattering from dislocations, then the measured value of A was a linear function of $(\rho_d/\rho_i)^2$ as predicted by calculations as then unpublished.

Recently two other staff members, M. Kaveh and N. Wiser, have published their results (*J. Phys. F: Metal Phys.* 10 L37 [1980]) on the effect of the coupling between anisotropic electron-dislocation scattering and isotropic electron-electron scattering on the electrical resistivity. Although Kaveh and Wiser are concerned with the anisotropic electron-dislocation scattering, they emphasize that the source of the anisotropy is unimportant, the significant fact is that it exists. In their view the relevant parameter is the ratio of anisotropic to isotropic electron scattering ρ_d/ρ_i, and they have solved the relaxation-time Boltzmann equation for the normal process contribution to A in terms of this parameter. Including a small term attributable to isotropic Umklapp processes gives a curve of $A(\rho_i/\rho_d)^2$ which, for potassium, is in agreement with the results of the measurements by Greenfield and with the results of other measurements for samples with lower dislocation densities.

Most recently Greenfield, Kaveh, Wiser and others have measured the resistivity of Li in the 1.2-4.2 K range. They found a pure T^2 dependence of ρ along with an anomalously large A

value which was ascribed to the anisotropy of the electron relaxation time for Li. These results are being submitted for publication.

Dr. M. Deutsch is setting up X-ray scattering experiments to obtain the structure factor S(k) of liquid helium ($k = 2\pi/\lambda$ is the wave vector). The behavior of S(k) near k = o gives information about the low-energy excitation spectrum which is thought to be a result of either phonons or spin density waves. Deutsch plans to measure S(k) to an accuracy of ~ 1% in the range $0.01\text{Å}^{-1}<k<o.3\text{Å}^{-1}$. He expects to observe the linear region above 0.08Å^{-1} and the departures from linearity in the range below 0.08Å^{-1}. In the course of setting up this accurate, low-temperature, small-angle X-ray diffraction experiment, Deutsch has developed some interesting devices: (1) a low-cost, precision V block formed from 2 centerless ground rods for positioning a heavy cryostat (*Rev. Scien. Inst.* 51 393 [1980]); (2) a low-thermal-conductance, demountable screwed joint (*Cryogenics* 19 273 [1979]); (3) a rigid, low-thermal-conductance support made from a perforated, thin-walled stainless-steel tube (*Cryogenics* 20 719 [1980]).

For the X-ray experiments on liquid helium, the diffractometer is placed inside the cryostat; it is a Bonse-Hart type diffractometer in which collimation is achieved by successive Bragg reflections of X-rays in a groove cut in a perfect single crystal (Si or Ge). By making the groove asymmetric with respect to the crystal planes, the diffractometer can be optimized for a particular experiment with respect to resolution, intensity, and S/N ratio.

In a recent pair of publications (*J. Appl. Cryst.* 13 252 [1980] and 13 256 256 [1980]) Deutsch has given the design principles of the asymmetric diffractometer and compared it with another type. He plans to begin the experiments on helium in the near future. (John R. Neighbours)

SOME RESEARCH IN EXETER

The University of Exeter is one of the more southerly universities in the United Kingdom. It was built during the boom of the late 1950s on a 300-acre estate adjacent to the city. Presently, the student population is approximately 5,000, almost all of whom have lodgings either in residence halls or in the surrounding community. Very few students at this university commute.

Cryogenics

Prof. A.F.G. Wyatt has recently come to Exeter from the University of Nottingham where he was active in cryogenic research. At low temperatures, the inhibition of heat flow between dissimilar materials at their mutual boundary (Kapitza resistance) is one of the major obstacles to the rapid attainment of thermal equilibrium. Often restricted in definition to mean the thermal boundary resistance between liquid helium and a solid, the Kapitza resistance can be understood semi-quantitatively in terms of acoustic impedance mismatch, and recognition of the fact that the cone of acceptance of phonons passing into the solid is very small as a result of the much lower sound velocity that occurs in liquid helium compared to that in a solid.

At Nottingham, Wyatt studied this effect. In 1978 he and one of his students, G.J. Page, measured the flow of phonons in both directions at a He-NaF interface (*J. Phys. C: Solid State Phys.* 11 4927 [1978]). They found two channels, or methods, for the transmission of phonons: a narrow cone, and a wide-angled background distribution which at high phonon frequencies is thought to carry most of the heat energy. At Exeter, Wyatt plans to extend these experiments to He-metal crystal interfaces. Prof. M. Yagub, on sabbatical leave from Ohio State University, will be collaborating on the project during the summer of 1981.

Ultrasonics

Adamantane ($C_{10}H_{16}$) is a saturated hydrocarbon which condenses into the face-centered cubic structure with the relatively large lattice parameter of 9.43 Å. This phase exists between 208.6 K, where there is an order-disorder transition to a tetragonal structure and the melting temperature of approximately 541 K. Determination of some of the 3 second-order elastic constants and their pressure derivatives were recently reported by Dr. J.R. Drabble and Mr. A.H.M. Husain (*J. Phys. C: Solid State Phys.* 13 1377 [1980]); at room temperature they measured 10 MHZ ultrasonic velocities at pressures up to 200 atmospheres. Crystals with propagation directions cut parallel to [100], [110] and [111] were used in a "sing-around" system (described below) which resulted in measurements with an estimated error of no more than 0.1% of the measured velocities. In this experiment, attenuation of the transverse waves was so high that the later echoes were of insufficient

amplitude to retrigger the pulser. Consequently, only longitudinal waves propagating in the three principal directions were measured; giving insufficient information to evaluate all three elastic constants. The results for C_{11} and $C = C_{12} + 2C_{44}$ are in agreement with previous measurements made at lower frequencies; those for $\partial/\partial_p(C_{11})$ and $\partial/\partial_p(C_{11}+2C)$ are new.

Analysis of the data for this molecular crystal was continued by assuming that the forces were central ones (the Cauchy relation, $C_{12} = C_{44}$, was actually obeyed to within about 3%) and that the interaction potential $\phi(r)$ used to calculate the elastic constants was of the Lennard-Jones type: $\phi(r) = Ar^{-n} - Br^{-m}$, where A and B are constants and the integers n and m describe the sharpness of the interaction. At equilibrium separation, the slope of ϕ is zero. This fact, along with the assumption of the Cauchy relation, and expressing the pressure derivatives of the second-order constants in terms of the third order constants, makes it possible to eliminate A and B and express the dimensionless ratios C_{11}/C_{12}, $\partial/\partial_p(C_{11})$, $\partial/\partial_p(C_{12})$ in terms of n and m only. Drabble and Husain used a computer program to perform the lattice sums for all the elastic constants up to third order for various values of n and m. They found the best agreement between the measured and calculated dimensionless ratios to be for n = 10 and m = 5 although this was not a very critical test, since these ratios are not very sensitive to the choice of n and m. In order to determine better the precise intermolecular elastic constants, experimental values of the other second- and third-order constants are needed.

The system used in this experiment was the standard sing-around type in which a pulser transmits a signal into the sample via a transducer, usually a piezoelectric such as quartz. A particular point on one of the echoes of the signal pulse is selected, usually by a movable gate, and used to retrigger the pulser. The pulse repetition frequency at which the system operates (sings around) is then proportional to the sound velocity and inversely proportional to the path length.

Recently Drabble constructed, from integrated circuits, a new dual sing-around system which utilizes a 10 MHz gated oscillator. The dual feature is found in the use of a second standard sample as a time delay to allow the echoes in the sample being investigated to die out before another triggering is initiated. This feature greatly decreases the interference between echo trains originating from different trigger pulses and allows the attainment of sensitivity of 1 part in 10^7. To maintain that level of sensitivity in operation, the system requires a temperature stability of ~10 mK in the standard sample. A description of this apparatus is being readied for publication.

Thin Film Electrical Conductivity

The study of electrical conduction in metals is a long-established British tradition. Very often data on thin metallic films have been analyzed in terms of a 1938 theory by K. Fuchs which contained two parameters: κ, the ratio of sample thickness d to electron mean free path λ_o, and the specularity parameter p, the probability that an electron incident on the surface will be specularly reflected. For foils, p has generally been taken to be nearly zero. Fitting data to this theory has led to strange conclusions such as the need for a temperature-dependent specularity parameter; or along with p = o, a temperature-dependent product of bulk resistivity and bulk electron mean free path. ($\rho\lambda_o = mv/ne^2$ where m is the electron mass, v is the electron velocity, n is the electron concentration and e is the electronic charge. In a metal, none of these factors is expected to vary other than slightly with temperature.)

A more recent but less-well-known theory by S.B. Soffer (*Journ. Appl. Phys.* 38 1710 [1967]) takes the surface roughness into account. Considering planar samples in the free electron approximation along with an angle-dependent specularity parameter and using isotropic bulk relaxation times, the Boltzmann equation was converted into a linear integral equation. Further simplifications result depending on the choice of the surface correlation length. In the uncorrelated case the ratio of bulk to thin-film resistivity is expressed as an integral of the same form as that given by Fuchs except that the specularity parameter p is a function of angle.

In a recent research paper, Dr. J.R. Sambles and Mr. K.C. Elsom pointed out that the integral expression "is no more difficult to apply than that given by Fuchs, being simply a two-parameter expression" (*J. Phys. F: Metal Phys.* 10 1487 [1980]). Sambles and Elsom have calculated the scattering integral for the uncorrelated surface roughness case for different values of the parameters $\kappa = d/\lambda_o$ and $r = t/\lambda_e$ where t is the surface roughness and λ_e is the electron wavelength. For both theories they have plotted families of normalized

curves of the fractional change in resistivity as a function of κ. For thick samples and/or high temperatures ($\kappa>20$), both theories give similar results in that the normalized fractional change in resistivity is independent of κ. For thin samples and low temperatures ($\kappa<1$), a Soffer-theoretic curve at constant r crosses the set of Fuchs-theoretic curves of varying p, therefore leading to the temperature-dependent specularity from the Fuchs viewpoint. Sambles and Kelsom noted that "the validity of Fuchs' theory has often been misguidedly assumed since, unless κ ranges from 10^{-2} to 1, it would be difficult to prove otherwise."

Using the Fuchs theory it usually has not been possible to exhibit a good fit to measured resistivity data for a particular film thickness over the liquid helium-to-room temperature range. Sambles and Kelsom have fitted several sets of measurements in the literature on Al with the Soffer theory with adequate resolution of previous anomalies.

The effect of surface roughness upon the resistivity of thin films has also been considered (*J. Phys. F: Metal Phys.* 11 647 [1981]). This enhanced resistivity is the result of island growth affecting p and λ_0 differently. Computer modeling of the islandizing of the films shows that at small thicknesses, the resistivity rises much higher than conventional surface scattering theory would predict. Existing experimental data in the literature on non-epitaxially deposited films are well described by this calculation.

Phase Transitions

Prof. A.J. Leadbetter is a professor of chemistry. During the 1950s, he was working on low temperature heat capacity measurements. In the intervening years his interests have changed, and now he is heavily engaged in neutron experiments on materials. Leadbetter was chairman of the local organizing committee for the March 1980 meeting of the Faraday Division of the Chemical Society on the subject of "Phase Transitions in Molecular Solids." At that meeting, he presented a paper on the phase transition and molecular rotation in tertiary butyl cyanide. Other work of this type is described in a semireview article on the study of molecular reorientational motions in molecular and liquid crystals using incoherent quasielastic neutron scattering (INQES) (*Phil. Trans. R. Soc. London* B290 567 [1980]) in which some new results on tertiary butyl chloride are presented. In this paper, INQES measurements on the liquid crystal isobutyl 4-(4'-phenylbenzylidineamino)-cinnamate (IBPBAC) show that in the smectic phases these long lathlike molecules have, in addition to rotation, the freedom to perform shuffling motions of several Angstroms extent parallel to their long axis. This ability is thought to provide a mechanism for some phase transitions. Other INQES measurements on ethyl 4-(4'-acetoxybenzylidine-aminocinnate (EABAC) along with NMR measurements (*Mol. Phys.* 40 741 [1980]) lead to similar conclusions about the motions of the EABAC molecules.

Leadbetter has a long-term collaborative program with Prof. G.W. Gray (Chemistry Department, Univ. of Hull). Along with others, the two have classified a previously unknown smectic phase of N-(4-n-pentyloxy benzylidene) -4-n-hexylaniline by means of optical, calorimetric, miscibility and x-ray diffraction experiments (*J. Physique* 41 507 [1980]). This phase is thought to have long-range order corresponding to weakly coupled 2D layers and only slight short-range positional order. It is a curiosity in that, as the temperature is changed, the phases change from ordered to less ordered to more ordered. That is, the phase which has 2D order appears between two phases which have 3D order. Leadbetter and Gray have studied the structure and correlations in this phase and others and are preparing a paper for publication.

Although the university is remote and I visited only a few projects, my impression was that of an active, viable research center. (John R. Neighbours)

NEWS AND NOTES

UNIVERSITY STAFFS START FIGHT AGAINST CUTS

Last month, university lecturers in the UK launched a vigorous campaign against Government plans to pick off weak university departments and strip some universities of their research (see *ESN* 35-4:177 [1981]).

At its council meeting in Cardiff, Wales, the Association of University Teachers (AUT) began efforts on May 15 to persuade members of Parliament that universities cannot cope with both spending cuts and the effects of a drop in the number of students. An executive motion was discussed that reaffirmed opposition to "redundancy," and sought to persuade universities that they can and should ignore pressure from the University Grants Committee (UGC) to apply financial cuts to individual courses, departments, or activities.

Shutting any faculty or department would entail dismissing some university staff members who have tenure. In preparation for a legal fight over tenure, the AUT has already set up a £100,000 ($200,000) fighting fund. It has also received opinion from legal counsel that some individual lecturers might be entitled to compensation of between £30,000 and £80,000.

The UK government is planning to cut spending on all higher education by 3½ percent in 1981-82, rising to 8½ percent over three years. When the effect of the fall in overseas student numbers is added, this should mean a drop of about 15 percent in university income. The UGC has calculated that this should mean the loss of at least 4,000 lecturers' jobs, plus up to 10,000 among other workers.

However, Dr. Rhodes Boyson, the minister in charge of higher education, told the association that the government would not alter its plans. According to Boyson, cuts in spending would have to be reflected, in the first instance, by a deterioration of the student/teacher ratio, and a reduction in the number of courses offered.

NEW SOLID-STATE LABORATORY FOR THIRD WORLD

The International Center for Theoretical Physics in Trieste, Italy, is setting up a major experimental laboratory for solid-state science in an attempt to encourage Third World interest in this important field. The laboratory will extend the activities of the center, already renowned for its theoretical work, to include experimental research.

According to Nobel laureate Professor Abdus Salam, the director of the center, the new laboratory will be a prototype for solid-state laboratories in the developing countries themselves. A feasibility study carried out by a team of experts at the center indicated that the research of the new laboratory should be related to the "already established excellence of the solid-state theoretical activity at the center", and should take advantage of the European Synchrotron Radiation Source, proposed to be set up near Trieste. The study concluded that the laboratory should be devoted to the production and characterization of materials (for example, single crystals of semiconductors and semiconduction alloys) and to the collection and dissemination of information on reliable sources of materials especially intended for visitors from developing countries.

Salam said that the laboratory's role as a data bank for materials would be unique. According to Salam, "Experimental scientists in the Third World face tremendous hardship in obtaining materials for their experiments. A small crystal that can easily be obtained in the industrialized countries may hold up their experiments for months, and sometimes even years. Our solid-state laboratory would produce single crystals for scientists from the Third World to use in their home laboratories. They will be able to write to us and have their requirements met within days."

The laboratory will also specialize in studies of the failure of electronic devices, so as to be able to act as a "service laboratory" for Third world scientists. This research is particularly relevant to the Third World—devices that function adequately in Western laboratories break down frequently in laboratories of developing countries. Horror stories of sophisticated and expensive apparatus meeting premature death are common.

According to Salam, the aim of this research would be to correlate the failures with their physical causes by using experimental techniques such as optical and electronic microscopy, X-ray diffraction, and spectroscopy.

Other areas of research at the laboratory will include chemisorption, a crucial link between the basic science of surfaces and the industrially important problems of corrosion and catalysis.

The Third World's energy problems will also receive attention. Salam summed up the role of the proposed laboratory as "a springboard for important progress in technology of interest to the Third World." The initial cost of equipment for the laboratory would be about $3 million, and running costs would be $1.5 million a year. The Italian government would provide most of this cash.

TIGHTER RULES ABOUT COMPUTER SCREENS COULD SET PRECEDENT

Europe's computer industry may be about to face a showdown over safe working conditions for computer operators. The Norwegian Labor Inspectorate recently introduced draft rules and guidelines for firms employing people who work with visual display units (VDUs). The rules say that nobody should work in front of a phosphor screen for more than 2 hours at a time without a break. This move is likely to draw strong protests from computer companies that have designed computer terminals for safer operation and from the companies that use the computers, which are now faced with reduced efficiency as the effective working day of their employees is shortened.

The draft rules also demand separate keyboards, and screens whose height, angle, and distance from the operator can be adjusted independently. High-frequency sound must be eliminated, and the eyes of operators should be checked every 2 years up to the age of 45, and every year after that.

The Labor Inspectorate is Norway's equivalent to Britain's Health and Safety Executive and the Occupational Safety and Health Administration (OSHA) in the US. Its draft rules, which would affect 25,000 terminals in Norway, are likely to be implemented.

The debate about the safety of screens continues unresolved in other parts of Europe, so the Norwegian initiative may lead to similar rules elsewhere. At the same time, manufacturers are spending large amounts of money developing screens that will conform to a new West German standard to be introduced in 1985. This makes demands similar to those of the Norwegian Labor Inspectorate for the design of screens but does not specify working hours.

COOLING TOWERS MADE OF POLYESTER

Conventional thermal power plants, in general, must be equipped with cooling towers, enormous concrete structures that can reach great heights. In recent tests made on such a tower of an electric power plant in Bouchain, northern France, however, French technicians demonstrated that in some cases the concrete in these towers can be replaced by polyester sheets.

The technique was implemented as the result of an accident. In this particular case, the concrete tower began to crack during operation. After repairs, the tower was started up again, but less than 4 weeks later it collapsed. Electricité de France, an electric power company, decided to try a method already studied but never applied to start up the tower again in the shortest time possible and with the least cost.

Only the base of the tower remained following the collapse. After its top was scraped, the decision was made to stretch a huge polyester sheet cylindrically above it. To support this sheet at a height of 63 meters, a metal mast had to be erected in the middle of the tower, consisting of 6 metal tubes crowned by a circular head to which cables could be attached. Once this was done, the polyester sheet, with a surface area of 1,000 m^2 and weighing 17 tons, could be stretched and maintained in a proper state of tension, using metal frames weighing 14 tons, with 4 rings at different heights.

The project took 10 men 3 months to complete. Nine kilometers of cable were required, and computers provided data which were used in the production and installation of each of the sections of the mast and membrane, and which accounted for all interior and atmospheric constraints.

The new tower was placed in service by the date originally scheduled, so production losses caused by the accident were kept to a minimum. Research is already underway to improve the technique. There are now plans to build cooling towers 140 meters high with frameworks which will employ both concrete and polyester.

ONRL STAFF CHANGES

Last month we welcomed aboard liaison scientist Dr. Nicholas A. Bond, psychologist, who came to ONR London from California State University at Sacramento. In June, we bade fond farewell to Commander John A. Holt, chief of the Naval Applications Division, who was transferred to the Naval Sea Systems Command in Washington, D.C. Commander Holt had been at ONR London since October 1978.

ONR COSPONSORED CONFERENCES

International Symposium on Locational Decisions (ISOLDE II), Skodsborg, Denmark, 15-18 June 1981.

Conference on "Modification of the Surface Properties of Metals by Ion Implantation," Manchester, UK, 24-26 June 1981.

VIth International Bioelectrochemical Conference, Kibbutz Kiryat Anavim, Israel, 28 June-3 July 1981.

9th International Conference on Operational Research, Hamburg, Germany, 20-24 July 1981.

International Symposium on Advances in Polymer Characterization, Durham, UK, 13-17 July 1981.

International Symposium on Hydrodynamics in Ocean Engineering, Trondheim, Norway, 24-28 August 1981.

Conference on Combinatorial Optimization, Stirling, UK, 24-28 August 1981.

4th International Symposium on the Chemistry of Novel Aromatic Compounds (ISNA 4) Jerusalem, Israel, 30 August-4 September 1981.

NATO Advanced Study Institute on "Static and Dynamic Properties of the Polymeric Solid State," Glasgow, UK 6-18 September 1981.

Fifth National Quantum Electronics Meeting, Hull, UK 23-25 September 1981.

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EUROPEAN VISITORS TO THE US SUPPORTED BY ONR LONDON

Visitor	Affiliation	Navy Lab(s) to be Visited
John Deane	British Aerospace Dynamics Group, EPC 67, P.O. Box 5, Filton, Bristol BS12 7QW, UK	ONR (25 June) NSWC White Oak (26 June) USNA (29 June)
Dr. Josef Katz	Dept. Mech. Engr., The Technion, Haifa, Israel	ONR (June)
Prof. P.C. Sabatier	Laboratoire de Physique Mathematique, Université des Sciences et Techniques du Languedoc, Montpellier, France	NRL, NSWC (Dahlgren) (June)
Prof. Evan Wyn-Jones	Dept. of Chemistry, Univ. of Salford, UK	NRL Marine Physical Lab., Scripps (June)

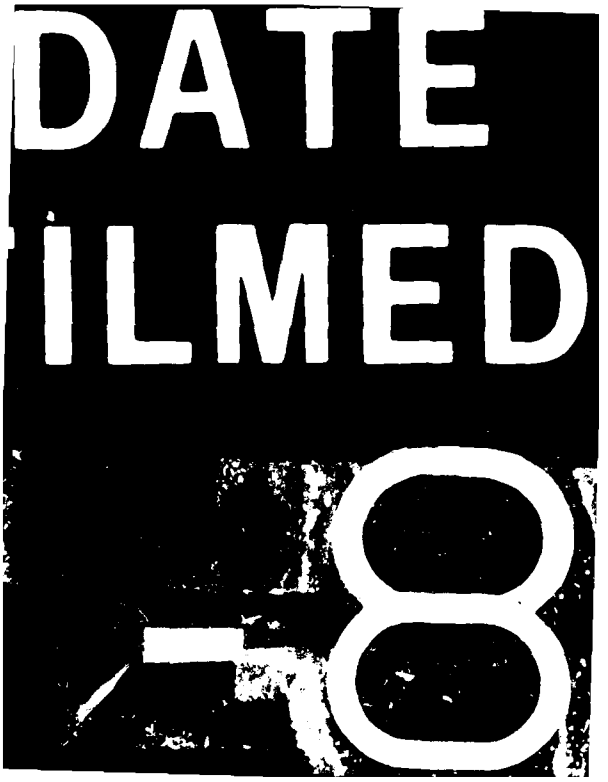
ONRL REPORTS

C-2-81 Fifth International Symposium on Air Breathing Engines, by J.R. Patton, Jr.

The Fifth International Symposium on Air Breathing Engines was held in Bangalore, India, in February 1981. The program was primarily directed to the discussion of aircraft turbine engines. This report contains comments on various papers that were of special interest to the author. It also contains the names of all the persons who spoke at the symposium and lists the topics they discussed.

R-3-81 Research in Electronic/Electric Engineering at British Universities, by Irving Kaufman

This is a summary report of research in electronic/electrical engineering at British universities encountered during the author's tour of duty as a liaison scientist with the London Branch Office of Naval Research, August 1978 to August 1980. The first section lists the agencies funding research in the UK, with some figures on the amount of funding and its distribution. This is followed by a brief discourse on British universities, with facts relevant to the student population in EEI at universities, and a comparison of British and American graduate and undergraduate programs. The final section contains, in summary form, information about the research found by the writer during his visits to 22 universities in England, Wales, and Scotland.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